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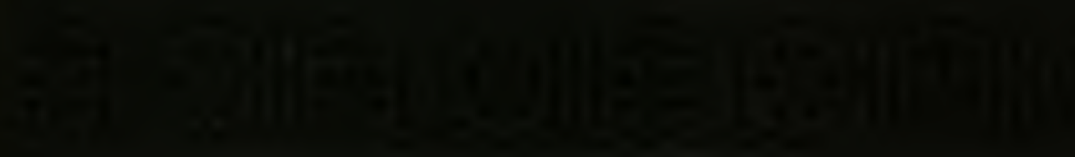

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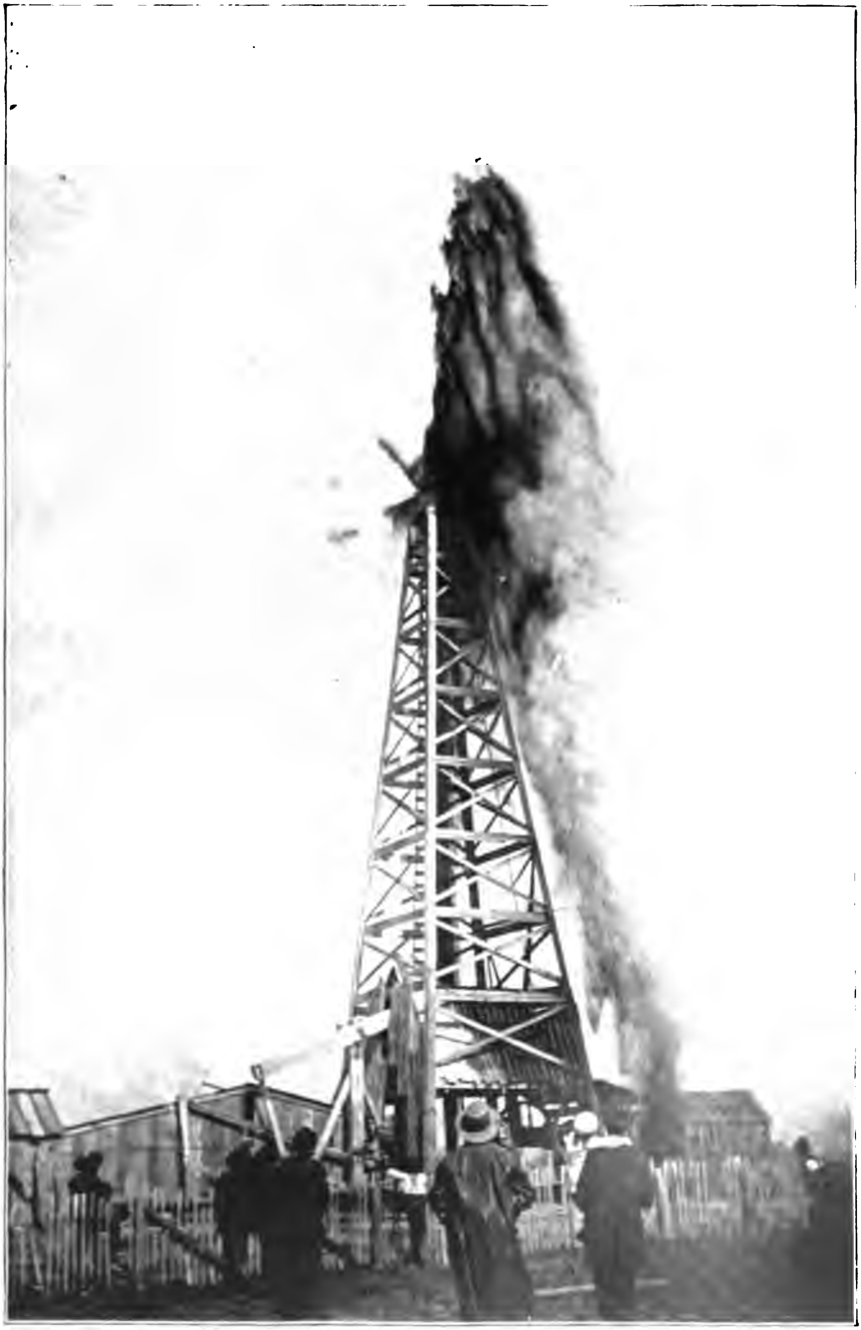

SHOOTING OF THE KIRKPATRICK WELL, NEAR VAN BUREN, GRANT CO., IND.

INDIANA.

DEPARTMENT

—OF—

Geology and

Natural Resources.

TWENTY-FIRST ANNUAL REPORT.

W. S. BLATCHLEY,
State Geologist.

1896

INDIANAPOLIS:
WM. B. BURFORD, CONTRACTOR FOR STATE PRINTING AND BINDING.
1897.

THE STATE OF INDIANA,
EXECUTIVE DEPARTMENT,
January 25, 1897.

Received by the Governor, examined and referred to the Auditor of State for verification of the financial statement.

OFFICE OF AUDITOR OF STATE,
INDIANAPOLIS, January 26, 1897.

The within report, so far as the same relates to moneys drawn from the State Treasury, has been examined and found correct.

A. C. DAILY,
Auditor of State.

January 26 1897.

Returned by the Auditor of State, with above certificate, and transmitted to Secretary of State for publication, upon the order of the Board of Commissioners of Public Printing and Binding.

CHAS. E. WILSON,
Private Secretary.

Filed in the office of the Secretary of State of the State of Indiana, January 26, 1897.

WILLIAM D. OWEN,
Secretary of State.

Received the within report and delivered to the printer this 1st day of February, 1897.

THOMAS J. CARTER,
Clerk Printing Bureau.

State of Indiana,
Department of Geology and Natural Resources.

INDIANAPOLIS, IND., January 25, 1897.

HON. JAS. A. MOUNT, *Governor of Indiana:*

DEAR SIR—In accordance with the provisions of the law under which the Department of Geology and Natural Resources of the State of Indiana was organized, I have the honor to submit to you the Twenty-first Annual Report of that Department. The contents of the Report pertain very largely to the economic natural resources of the State and embrace the results of the work accomplished by the different divisions of the Department during the calendar year 1896.

Very respectfully,

W. S. BLATCHLEY,
State Geologist.

ASSISTANTS.

T. C. Hopkins, now of State College, Pa.	Building Stones.
C. E. Siebenthal, Bloomington, Ind.	Building Stones.
Geo. H. Ashley, Indianapolis, Ind.	Coal.
J. T. Scovell, Terre Haute, Ind.	Local Geology.
Aug. F. Foerste, Dayton, Ohio	Local Geology.
W. A. Noyes, Terre Haute, Ind.	Chemist.
Malverd A. Howe, Terre Haute, Ind.	Physicist.
J. C. Leach, Kokomo, Ind.	Supervisor of Natural Gas.
C. F. Hall, Danville, Ind.	Supervisor of Oil Inspection.
Robert Fisher, Brazil, Ind.	Inspector of Mines.
James Epperson, Linton, Ind.	Assistant Inspector of Mines.

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INTRODUCTORY.

The people of Indiana, engrossed with the cares and duties of their respective vocations, too seldom pause to consider the great natural resources of their State, or the high rank which that State is rapidly assuming as a mineral producing and manufacturing center.

Twenty years ago Indiana was noted mainly for her agricultural products—her crops of corn and wheat, her droves of fine cattle and hogs, her blue grass pastures and her large areas of native timber lands. To-day she still ranks high as an agricultural State, but to the world at large her mines of coal, her quarries of building stone, her deposits of clay, her petroleum wells and her large area of natural gas territory are her most valuable possessions. They, and not her soil, are the resources which are now attracting so rapidly within her bounds capital and population from other States and nations of the world.

Ranking in area of square miles but thirty-fourth among the forty-five States of the Union, Indiana, in 1895, stood sixth in the production of coal, fourth in the production of petroleum, second in the production of natural gas, seventh in the production of building stone and sixth in the value of her clay products. According to careful computations made by the United States Bureau of Mineral Resources the value of the five resources above named, produced in Indiana in 1895, amounted to the vast sum of $17,125,000.

It is, in my opinion, the province of the Department of Geology and Natural Resources to investigate these great natural products of our State, to gather information concerning their distribution, their abundance and their fitness for the uses to which they are put, and to make known that information through the proper channels to all persons interested in such resources.

A secondary province of the Department is the collecting of information concerning the great rock formations of the State—their outcrops, their fossils, their relations to the overlying soils and to the streams which flow above or through them. Such information, when properly compared and correlated, will in time furnish the basis for an *accurate* geological map of the State—something that yet has never been published; and for a volume which will give in detail to those interested in technical geology more exact information than is now available concerning the origin and history of each of the great geological horizons represented in the State.

When I was chosen as the Chief of the Department of Geology I resolved to abandon, for the most part, the unscientific method, formerly in vogue, of county surveys, since the civil boundaries of a county have nothing to do with the limits or boundaries of a natural resource or geological formation. In its stead I adopted the plan of taking up each of the great natural resources of the State and preparing a monograph or special report thereon; said monograph to be based upon months of actual field investigation and to include maps, cuts, engravings and tables of chemical and physical tests. My first report, issued in May, 1895, was prepared on the plans established and treated in detail the following resources:

First. The clay deposits accompanying the coal measures of the State.

Second. The sandstones of western Indiana.

Third. The whetstone and grindstone resources of southern Indiana.

The present volume is the twenty-first in the series of reports dealing with the geology of the State and the second issued during my administration. It shows in detail the results of the work accomplished by the Department during the calendar year 1896.

THE NATURAL RESOURCES OF INDIANA.

FUELS.

At the present time the relative importance of any State or nation in the world is very largely determined by the amount of available fuel which that State or nation possesses. A fuel is but a form of matter containing within itself a stored supply of potential energy in the form of heat. When that heat is set free by combustion it can be utilized by man to perform work. With heat he at present brings about or produces five-sixths of the mechanical motions of the world.

The heat found in the various kinds of fuel is a stored supply of energy upon which we are constantly drawing—oftentimes lavishly—without being able to add one iota thereto. It is the richest inheritance which has come down to man from the ages past. Millions of years have been necessary for its accumulation. At the present rate of consumption a few thousand will suffice for its total dissemination. Its source, the sun—that wonderful fountain of all terrestrial energy—the heat in any fuel has been caught by the tiny cells of plants in ages past, has been used in promoting their life and growth, has been stored within their tissues or transmitted to some form of animal life, and in time the plant or animal with its stored supply of heat, has, by chemical and physical forces, been changed into what we are now pleased to call coal, petroleum and natural gas.

These fuels are the most valuable resources of our State to-day. We are drawing upon them with a lavish hand. They came to us without great labor, as comes oftentimes the accumulated riches of a toiling and thrifty parent to a spendthrift son, and, as with the latter, "come easy, go easy," seems to be our motto. Once again would I repeat "that no coal, no natural gas, no oil is being formed beneath the surface of our State to-day. Our present supply of each of these fuels will never increase, but ever diminish. Each constitutes a great reservoir or deposit of reserve energy upon which the people of the present generation are daily drawing without adding thereto. Like a bank account under the same conditions it is only a question of time until it will become exhausted."

Coal.—Indiana contains nearly 7,000 square miles of workable coal-fields. This area occupies a part or all of nineteen counties in the southwestern portion of the State, extending from Warren County southward 150 miles to the Ohio river. At least seven distinct veins of workable thickness occur in the State. These vary from three to eleven feet in thickness and aggregate in a few places from 25 to 28 feet. From this area in ten years—1886 to 1895, inclusive—was mined 33,355,988 tons of coal, valued at $36,673,059. In 1896 the number of tons mined in the State was 4,068,124, or 243,960 tons less than in 1895. The decrease was due to the extended strike among the bituminous miners which began in May, 1896, and was continued, in some localities, until December.

The coals of Indiana are of three varieties, which in certain localities merge into one another. The most valuable of these from a manufacturing point of view is the "block" coal, or, as it is generally known, the "Brazil" block. It possesses a laminated structure, and is composed of alternate thin layers of vitreous, dull black coal and fibrous mineral charcoal. It can be mined in blocks as large as it is convenient to handle. These blocks split readily in the direction of the bedding plane, but in the opposite direction are broken with difficulty. It is as pure as splint coal, almost free from sulphur or phosphorus, and has the softness and combustibility of wood. In burning it swells so little that its expansion is scarcely perceptible, does not change form, and never cakes or runs together; hence, it is a most valuable fuel for the blast furnace and the cupola of the iron founder.

For steam and household purposes it likewise has an unrivaled reputation. It burns under boilers with a uniform blaze that spreads evenly over the exposed surface, thus securing a more uniform expansion of the boiler plates. Its lack of sulphur also causes it to have but little detrimental effect upon the boiler, grates, or fireboxes. In household grates it burns with a bright, cheerful blaze, like hickory wood, making a very hot fire, which, for comfort and economy, can not be surpassed by any fuel except an abundant supply of natural gas.

Block coal occurs in three counties—Clay, Owen and Parke. Up to the present the largest supply has been derived from Clay County, where it was first developed. Much of the area in the immediate vicinity of Brazil has been exhausted, but new developments have been made in northern Clay County and in the two southeastern townships of Parke County. A very fine deposit of this coal underlies several square miles in the immediate vicinity of Patricksburgh, Owen County. Owing to a lack of railway facilities, this deposit is as yet undeveloped except for local use.

The bituminous or caking coals found in Indiana vary much in character and purity, but their average will compare favorably with that of those found in any other State. They comprise by far the greater bulk of our coals, underlying about 6,500 square miles of territory. The thickest bed which has come to my notice is about three miles north of Petersburgh, Pike County, where the vein worked is 10 feet 2 inches in thickness and of most excellent quality.

Bituminous coal lands, as yet undeveloped, are found in many parts of the coal area, the best probably occurring in northwestern Greene, northeastern Sullivan, and northern Pike Counties. In a number of localities, notably at Mecca, Parke County, and in the eastern half of Daviess County, a "semi-block" coal, ranking in quality between the true block and ordinary bituminous, occurs. It does not cake when burned and contains a comparatively small percentage of sulphur and other impurities.

Cannel coal, a dull, textureless variety of the bituminous, rich in gaseous constituents, occurs in several of the southern counties, but is mined only at Cannelsburgh, Daviess County. Here the vein varies in thickness from two to four feet and directly overlies a vein of "semi-block" two feet thick, the two being worked together. The cannel coal breaks irregularly, with a conchoidal fracture, and does not smut the skin when handled. It is more valuable for manufacturing illuminating gas than for fuel.

Since 1878 but little concerning Indiana coals has been published in the reports issued by this Department, and that little only in the introduction to those reports. Thousands of bores have been put down to prove the presence of veins of workable thickness and many shafts have been sunk to known deposits close to railways. Much valuable information has thus become available, which, when gathered and properly correlated, will show the exact limits of each of the seven great coal veins of the State.

Realizing that the coal area of Indiana is destined in the future to become a great manufacturing center, a comprehensive survey of that area was planned, and in July, 1896, Dr. Geo. H. Ashley, a graduate of Cornell and Leland Stanford Universities, and a specialist in coal geology, was put in charge. His time for the remainder of the season was spent in field work in Knox, Daviess and Martin Counties. Next season, with able assistants, he will resume this field work, and will continue it until the entire coal area is accurately mapped, when a special report of the field as a whole will be prepared and published as a single volume. This will be the first complete report ever issued on Indiana coals, since in the previous papers thereon, the last of which was issued eighteen years ago, the subject was treated in isolated county areas and scattered through seven successive reports of this Department—now long out of print and almost impossible to obtain.

In the present volume will be found a paper on the "Composition of Indiana Coals," by Prof. W. A. Noyes, professor of chemistry at the Rose Polytechnic, Terre Haute, Indiana. I had this paper prepared at the suggestion of several of the leading glass and steel manufacturers in Indiana, who are now using natural gas for fuel. These gentlemen have come to realize that they will, in a few years, have to remove their factories to other States or use Indiana coal, now distant from their factories. Instructions were given the State Mine Inspector and his assistant to collect fair *average* samples of coal from a number of the leading mines in the State. Nineteen such samples were secured and sent Prof. Noyes, who has made a complete chemical analysis of each and at the same time determined its heat value and steam producing value. Seven samples of Pittsburgh and West Virginia coals were also secured from the Marmet Coal Company, of Cincinnati, Ohio, and the same facts concerning them were determined in order that a comparison could be made of analyses determined under the same conditions.

This comparison shows the quality of the Indiana coals to be much better than expected; the average steam producing value, or evaporative effect, of the nineteen samples being 12.8 pounds, as against 13.7 pounds, the average for the foreign coals. The small value of .9 pound in favor of the Pittsburgh coals is more than offset by their additional cost of transportation.

Full statistics of the coal industry of Indiana, as well as an account of the condition of each mine operating more than ten men, is given in the annual report of the State Mine Inspector in another part of this volume.

It is my opinion that the law should be so changed as to require the examination, at least once each year, of every mine operating in the State, regardless of the number of men employed. Many mines employ from six to eight men, and the aggregate amounts to a large number. The life of any one of these men is as valuable as that of a man working in the larger mines, yet under the present law they receive no protection whatever. The air where they work is often extremely foul—man-shafts are more often lacking than present, and too little attention is given to the condition of the roof. Some of these abuses could at least be ameliorated by the occasional visit of an Inspector invested with power to better the conditions where possible.

Petroleum.—The production of petroleum in the Indiana field amounted in 1896 to 4,659,000 barrels. When it is remembered that this field had its beginning only in 1891, its growth will be seen to have been a phenomenal one. Especially was this true of the year 1895, when a gain of nearly 700,000 barrels, or 18.9 per cent., was made over the preceding year. In 1896 the gain was but 272,850 barrels, or 6.2 per cent. The general depression in business, the excitement incident to a national election, and the much lower average price of oil prevented the sinking of as many wells in 1896, there being but 1,180 new bores put down as against 1,267 in 1895. Of these, 158 were dry. Of the producing wells the aggregate initial output was 25,372 barrels, or an average of 24.8 barrels to the well, as against 33,718 barrels in 1895, or 30.6 barrels per well.

In obedience to a popular demand for a general account of the petroleum industry in Indiana and for an accurate map of the productive territory, the writer spent the greater parts of the months of June, September and October, 1896, in the petroleum field, gathering data for such a report and map. Both are presented in the present volume, and both can be relied upon as being fairly exact up to January 1, 1897.

The map will show that the area producing oil in Indiana is much smaller than has been generally supposed or than has been marked as oil producing territory on the geological maps published in the past by this Department.

It comprises about 400 square miles in the counties of Adams, Jay, Blackford, Wells, Grant and Huntington. A careful study of this field leads me to believe that the production therein will never be much greater than it is at present. The field will, however, doubtless enlarge, especially to the southward, and will in time comprise much of the territory now producing gas. This opening up of new territory will, of course, increase the yield, and may increase the general average production, which, on January 1, 1897, was about four barrels per day for each of the 3,442 wells then producing oil.

A number of the first wells put down are beginning to show signs of failure, and a few have already been abandoned, but this is to be expected where one is daily drawing upon a reservoir to whose contents nothing can be added.

In the paper which follows, I have endeavored to make plain the views of the most noted scientists regarding the origin of petroleum. With few exceptions they conclude, and the facts collected in the Indiana field all tend to verify that conclusion, that petroleum, like coal and natural gas, is a product of past ages. As Prof. Orton has well said, "Every producer of petroleum knows that a field begins to die the moment it begins to live." The age of a productive oil well in the United States does not generally exceed five years, and is often much less, and the longest life of the best American field has never yet attained to a score of years.

Samples of oil and water containing oil are constantly being received at my office from stations outside the present producing field. For the most part they have been gathered near the surface, and the persons collecting them believe that they are "surface indications" of a large supply of the precious liquid In this they are mistaken, for the sample collected, if traced to its source, will be found to have exuded from a crevice in some neighboring stratum of rock, or to have come from some large mass of vegetable matter, partially or wholly covered with water or mud. Every shale, sandstone or limestone in the State contains oil in greater or less amounts, and even where the amount is infinitesimally small, enough may collect to exude from a crevice and produce a showing upon some near-by surface of water.

Again, many letters are received, asking: "What are the surface indications of gas or oil?" To all such inquiries I reply that there is absolutely no such thing as a "surface indication" of either of these resources. Where they occur in paying quantities in Indiana, they are found at depths varying from 700 to 1,500 feet below the surface, and no human being can say with certainty that a bore put down, even in the best prospective territory, will yield either in paying quantities.

Natural Gas.—The area producing this valuable fuel has not been enlarged by new developments during the past year. It still continues approximately at 2,500 square miles, which is larger than is possessed by any other State in the Union. The wells in the outer zone of this area, which embraces a strip about fifteen miles in width around the entire field, show a much decreased flow, and in many instances have become worthless through the influx of salt water or petroleum. In another year or two much of this outer zone will have ceased to yield, and the natural gas area will have diminished to about two-thirds its present size. The middle zone, probably twenty miles in width, yields much of the gas which is piped to cities outside the field. A majority of the wells in this zone have begun to show signs of water, but up to the present this has not been in sufficient quantity to cause much decrease in the supply of gas. The average pressure of this part of the field has, however, according to careful measurements, made by Mr. Leach, decreased about twenty pounds during 1896.

The third zone, or heart of the field, embraces about 400 square miles in Madison, Delaware and Grant counties. It contains some of the best producing wells in the State and, as yet, shows but few signs of water or other influences tending to diminish the supply of the gas. The rock pressure over this area shows, however, an average decrease of about fifteen pounds over that of 1895.

A careful study of the excellent report on the present condition of the field, furnished by Mr. Leach and printed in another part of this volume, can but lead one to believe that the supply of natural gas is slowly but surely failing and that manufacturing establishments that consume a half million or more feet a day can not be greatly multiplied in any part of the Indiana field without rendering a speedy exhaustion of the supply a certainty. When petroleum or salt water invades a former gas rock it comes to stay—the petroleum until it is pumped out, the water permanently, since the supply of that liquid is too great to attempt to overcome.

As mentioned in my former report, much undeveloped gas territory is still held in reserve in various parts of the Indiana field, and upon it manufacturers can draw for a limited period after the present producing territory is exhausted. That the leading manufacturers realize the coming failure of the gas supply is evinced by the number of letters and inquiries received from them on the subject. They know by experience the value of a gaseous fuel, and it was, if possible, to retain their factories within the State that the investigations were started concerning the composition of Indiana coals and their fitness for conversion into gaseous fuel.

Meanwhile each consumer of natural gas should use every means at his command to husband the supply by stopping at once all unnecessary use or wanton waste. By so doing, the length of time for which the gas can be supplied for household use can be materially lengthened, and another decade may even go by before the last of this valuable and most convenient fuel will be consumed.

Bituminous Shales.—The Genesee shales of the Devonian age are rich in bitumens, which, when better means have been perfected, can be extracted and used for fuel and lighting purposes. These shales occupy a large area, extending from New Albany, on the Ohio River, to Delphi, Carroll County, at the former place being 104 feet in thickness. Mr. Hans Duden, an experienced chemist of this city, has recently made a special study of the shale as exposed at New Albany and has determined accurately the percentage of bitumens which it contains. He has given the results of his investigations and experiments in a paper prepared for the present report. In this he shows that 8.5 pounds of the black slate yielded by distillation 45 gallons of gas, which, when burned as an illuminant, showed itself to be 22 candle power in quality.

In Scotland and Germany these shales are utilized on an extensive scale, the former country producing annually from them 60,000,000 gallons of crude oil and 25,000 tons of sulphate of ammonia, the latter a valuable fertilizer. Mr. Duden claims that "taking into consideration its thickness of more than 100 feet, the State of Indiana possesses in this Devonian slate a reservoir of power greater than the coal seams, which can furnish an almost inexhaustible supply of oils for illuminating, heating and other purposes, providing the proper means of utilization are devised." The paper of Mr. Duden merits careful attention from those especially interested in the future problems of a source of light and heat.

RESOURCES OTHER THAN FUELS.

BUILDING STONE.

Oölitic Limestone.—"Indiana is widely known as the most important State in the Union in its output of limestone for fine building and ornamental purposes." So says that noted authority, Mr. W. C. Day, in "Mineral Resources of the United States" for 1894.*

Mr. Day refers especially to the Bedford oölitic stone, which has long been noted among architects for its strength and durability. It is of a uniform rich gray color and close texture, and is comparatively soft when first quarried, but hardens on exposure. On account of the ease with which it can be quarried, sawed and dressed for builders' use, it can be put on the market for a less sum per cubic foot than any stone of equal grade in the United States. Within the past fifteen years it has become an exceedingly popular building stone, not only in Indiana and adjoining States, but in the Eastern cities, where many of the private residences of the richer citizens have been constructed from it.

Although the oölitic stone has long been known as one of the leading resources of the State, no detailed account of the area in which it is found has before been published, nor has any map showing its exact distribution ever been prepared. Believing that the quality of the stone and the extent of the industry demanded a more important recognition from the Department of Geology, a special survey of the oölitic region was planned and put in charge of Mr. T. C. Hopkins, the specialist in building stone, who prepared the paper on the "Sandstones of Western Indiana," for my first report, and Mr. C. E. Siebenthal, who had already done much geological work in the oölitic region. These gentlemen have prepared an exhaustive paper on the Bedford oölitic stone, which is presented in the body of the present report.

The text of this paper gives in detail the general geologic features and stratigraphy of the oölitic belt, the structural features and properties of the oölitic stone and descriptions of the principal quarry areas and of areas deserving of development. It also gives an historical account of the development of the oölitic limestone industry and its present status.

Accompanying the paper are maps showing accurately the distribution of the limestone through Owen, Monroe and Lawrence Counties, as well as special maps on a larger scale, showing in detail the distribution and development of the quarry industry in the vicinity of Romona, Owen County; Stinesville, Ellettsville, Bloomington and Sanders, Monroe County, and Bedford, Lawrence County.

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* P. 498.

Nearly 150 chemical and physical tests of the stone have been made especially for this report. These tests show that the best grades of the stone contain 98.5 per cent. of pure carbonate of lime, which is practically indestructible by atmospheric influences; and that the crushing strength ranges between 4,500 and 7,000 pounds per square inch, for specimens quarried within the year.

Full statistical tables of the production in the past and present are also given. From these we learn that, at a low estimate, $2,672,000 are invested in the industry, and that the value of the product for 1896 was $1,264,210, which, owing to business depression and exceeding low price of the product, was $200,000 less than in 1895.

Crystalline Limestones.—These limestones belong mostly to the Niagara formation and contain more or less magnesium carbonate in their composition. They are much harder than the oölitic stone and, as a consequence, can not be sawed. As a rule they are not building stones of a high grade, yet they are used extensively for building purposes in eastern Indiana, where they occur most abundantly. In Decatur County alone there are more than twenty quarries, most of which, however, are operated on a small scale. The stone is also used extensively for bridge purposes. Dr. Aug. F. Foerste, in his paper on the "Geology of the Middle and Upper Silurian Rocks of Southeastern Indiana," published in this report, gives the location and stratigraphy of a number of deposits of this stone which in future will well pay for development.

In some parts of the State true calcium limestones occur, which are highly crystalline in character. These are called "Indiana marbles." They admit of a fine polish and make most handsome mantels and other interior decorations; but in general the deposits are too thin to be quarried, with profit, for building purposes. Large deposits of these "Indiana marbles" occur near Temple and English, Crawford County; at Pipe Creek, Miami County, and in the southwestern corner of Fayette County.

Sandstones.—In the last report of this Department was an extensive paper on the "Sandstones of Western Indiana," prepared by Prof. T. C. Hopkins. It was accompanied by maps showing the exact location of quarries now worked, and of deposits worthy of development, and contained the results of numerous physical and chemical tests showing the fitness of the stone for building and bridge purposes.

In that report it was shown that sandstones of excellent quality, and in commercial quantities, occur at a number of localities in western and southwestern Indiana.

These sandstones are of two varieties. First, the *Mansfield Sandstone*, occupying a strip from two to ten miles or more in width, extending from the north part of Warren County 175 miles in an east of south direction to and beyond the Ohio River. While the Mansfield sandstone is soft, friable and easily worked, it hardens by exposure and becomes in time one of the most durable rocks in the State. Two color varieties occur: (a) A handsome dark brown, especially suited for business blocks, and for lintels and cornices of buildings whose fronts are constructed of pressed brick, since the rain never discolors small portions of such stone, and the brick walls are therefore permanently free from those unsightly, mouldy-looking streaks which soon appear where limestone is used for finishings; (b) buff and gray, well fitted for building and bridge foundations, or, where of the best quality, for business fronts. The brown stone is quarried extensively at St. Anthony, Dubois County, and large and valuable deposits of it, as yet undeveloped, occur near Bloomfield, Greene County, and Portland Mills and Mansfield, Parke County. The gray and buff varieties are quarried on a large scale at Attica, Williamsport and Fountain, in Fountain and Warren counties.

Second, *the Coal Measure Sandstones*, which occur at horizons above the Mansfield sandstone at a number of localities in the coal bearing counties of the State. These stones are usually light blue or light gray in color, easily worked, very durable, and are rapidly coming to the front for building purposes. Extensive quarries are in operation at Worthy, Vermillion County; Riverside, Fountain County, and Cannelton, Perry County.

The capital invested in the sandstone industry in Indiana in 1895 was $610,000, and the output for the year was valued at $118,000. The undeveloped deposits of sandstone in the State are sufficient in quantity and in quality suitable to merit the careful attention of capitalists in search of good investments.

STONE FOR OTHER USES.

Flagging and Curbing.—Extensive deposits of thin bedded Niagara limestone, especially fitted for flagging and curbing, occur in several portions of the State, notably near Laurel, Franklin County, and Wabash, Wabash County. At the former locality the deposits are especially large, sections 17, 18, 19 and 20 of Laurel Township being for the most part underlaid with it. It can be quarried more easily and with less expense than any other stone of a similar nature in the State, the natural seams and even bedding doing away largely with the necessity for drilling and blasting. The stone is of an excellent color, and is harder and more durable and therefore cheaper in the long run for curbing than either the oölitic limestone or the Berea, Ohio, sandstone. Numerous small quarries have been opened, but as yet the railway facilities are insufficient. With a switch from the Whitewater railway constructed to two or three of the best deposits, this stone could be put on the market in quantity for a lower price and yet with a greater profit than is now secured; and its superior quality would soon lead to its extensive adoption for those purposes for which it is so well fitted.

Lime.—In the vicinity of Huntington, Huntington County; Delphi, Carroll County, and Logansport, Cass County, deposits of Niagara limestone are found which are especially suited for the production of lime for building purposes. At Huntington and Delphi the manufacture of lime is carried on on an extensive scale, the value of the yearly output at the two points approximating $250,000. The product is noted throughout the eastern United States for the excellence of its quality, and is much sought after by builders and contractors.

The oölitic limestone of southern Indiana has not proved itself fitted for the production of lime, but a formation immediately overlying the oölitic has been extensively used, and large kilns are now producing from it a good quality of lime at Mitchell, Lawrence County, and Romona, Owen County.

Cement Rock.—Hydraulic limestone suitable for the manufacture of cement occurs in a number of localities in southern Indiana. The largest deposits are found in Clark County, extending up the valley of Silver Creek for about fifteen miles above Clarksville. From these the Louisville Cement Co., in 1895, manufactured 865,000 barrels of rock cement, valued at $413,200. This cement is used in mortar for building, in the foundation of asphalt and brick pavements, in the construction of tunnels, bridges, dams and aqueducts; in the lining of cisterns and cellars, and for many other purposes. Cement rock of good quality occurs also in Scott and Jennings Counties, and recently a large deposit has been discovered at Derbyshire Falls, near Laurel, Franklin County. In the northern part of the State a large deposit also occurs near Wabash, Wabash County, which has been much used locally. The rock belongs to the Corniferous epoch of the Devonian age. The industry is a growing one, and Indiana already ranks second in the Union in the manufacture of the product.

Whetstone and Grindstone Rocks.—The fine-grained silicious rocks in Orange and Martin Counties have long been used for the manufacture of abrasive materials. In the last volume issued by this Department was a full report on the whetstone and grindstone industry of the State, prepared by Mr. E. M. Kindle. This was accompanied by an accurate geological map of the area mentioned. Indiana ranks second among the States of the Union in the production of whetstones and grindstones, being excelled only by Arkansas. The output in this State is not large, being in 1895 but 300,000 pounds, valued at $15,000. The demand, however, is constantly increasing, and if better railway facilities were provided the industry would soon become a prominent one in the area which contains the raw material.

Marls.—Many inquiries were received at this office during 1896 relative to marl deposits in Indiana. Marl is a very nearly pure carbonate of lime. The larger deposits in the State are found in the vicinity of the lakes of northern Indiana, especially near Silver Lake, Dekalb County; Lime Lake, Steuben County;* Rome City, Noble County; Rochester, Fulton County, and North Liberty, St. Joseph County. These "shell marls" are pure white in color, and are generally supposed to be the remains of fresh water shells. They probably owe their origin, however, to deposits from calcareous springs, the waters of which contain much lime in solution. These marls are coming into extensive demand for the making of Portland cement, which is made from carbonate of lime and clay, and also for making disinfectants and deodorizers.

The Bedford oölitic stone, composed, as it is, of 98 per cent. pure calcium carbonate, would seem to be suitable, after grinding, for the making of Portland cement. Experiments looking to this end have been recently carried on, which I understand have proven successful, and a company known as the Bedford Portland Cement Company has been organized, and will soon erect a large factory for making the cement near Bedford, Lawrence County.

CLAYS.

During the past decade an enormous expansion of the clay industries has taken place in the United States. The utilization of vitrified brick for roadways has created a new and distinct industry, thousands of miles of streets throughout the West having, since 1890, been paved with this material. The disappearance of our forests, and the consequent rapid advancement in the price of all kinds of lumber, has led architects and builders to investigate more carefully the value of clay products for structural purposes. These investigations have resulted in valuable discoveries concerning the chemical constituents and properties of clays; have suggested the invention of new, or the improvement of old forms of machinery and kilns, for their manipulation and burning, and have proven their unexcelled fitness for many purposes to which stone, wood or other materials were previously put.

As a proof that the general public is beginning to appreciate this fitness, one has but to note the rapidly increasing use of terra cotta and pressed brick for the fronts of business blocks and the more fashionable and costly private residences; of clay shingles for their roofs, and of encaustic tiles for their floors and mantels. Indeed, all present signs point to clay—that most widely distributed and cheapest resource known on earth—as the leading factor in the future structures built by man.

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*A large deposit also occurs on the shores of a small lake in sec. 3, tp. 37 n., r. 13 e., Steuben County. For analysis see Ind. Geol. Surv., 1872, 41.

That Indiana has not kept pace with her sister States in this rapid development of clay industries is known to all who have given the matter any attention. Recent and accurate statistics, compiled by the United States Bureau of Mineral Resources, show that of the total value of clay products manufactured in the United States in 1895, Ohio made 16 per cent.; Pennsylvania, 13 per cent; Illinois, 11 per cent.; New York, 9 per cent.; New Jersey, 7 per cent.; while Indiana made but 5 per cent., and they largely of the cruder kinds. The reason that this State ranks as low as it does, lies not in the lack of quantity or variety of raw materials, nor in the lack of enterprise and capital among her citizens, but almost wholly because of the ignorance prevailing concerning the location and quality of its clay deposits and the uses to which they are capable of being put.

In order to overcome this ignorance, and to make plain to the people of the State, and the nation, something of the true value of Indiana clays, a careful study of the "Clay Deposits of the Coal-bearing Counties of Indiana" was made in 1895, and a detailed paper thereon was published in the last report issued by this Department. This paper proved conclusively that with the exception of some of the clays used in the making of the better grades of terra cotta, encaustic tile and china ware, Indiana possesses in great abundance the raw material for making every kind of clay product used within her bounds.

The kaolin of Lawrence, Martin and Owen Counties can not be excelled in quality, numerous chemical analyses showing it to be composed of more than 98½ per cent. pure silicate of alumina. It has been proven by practical use to be well suited for the making of porcelain ware, and also for sizing for the finer grades of wall and letter paper. Experiments have within the last year shown it of excellent quality for being converted into the better grades of ultramarine, a pigment, of which 25,000 pounds or more are imported weekly at a cost of 10 to 25 cents per pound. It can also be used for making the finest grades of refractory ware, such as retorts, glass pots, glass tanks, etc. At the largest known deposit, near Huron, Lawrence County, thousands of tons of this purest of clays can be seen, comprising a stratum five to eleven feet in thickness; yet, since 1891 not a pound has been put to use. A great mineral resource of untold value—there it lies, unworked, unutilized, awaiting only the coming of energy and capital to make it up into many kinds of products which are now brought into our State from distant lands.

Millions of tons of shales and underclays, well fitted for making the best grades of paving brick, exist in the coal-bearing counties of Indiana. These clays lie in the closest proximity to the fuel necessary to burn them; yet, previous to 1896, of the $884,667 expended by twenty-seven towns and cities (not including Indianapolis) of the State for paving brick, no less than $647,022 were sent to Ohio and West Virginia for that product.

These underclays and shales can also be made into the best of sewer pipe, roofing tile, terra cotta, hollow brick, "stone" pumps, pressed front brick, etc. A number of large factories have been recently erected at Brazil, Terre Haute, Clinton, Veedersburg, Cayuga and other towns for utilizing these clays. These factories have, for the most part, been kept very busy, even during the dull seasons of 1895 and 1896, the demand for their products being in many instances greater than the possible supply. They have proven by practical experience that the shales and underclays of the coal measures are in every way fitted for manufacturing each of the products above mentioned. These factories are but the forerunners of others yet to come, for the raw material is there, the fuel necessary to burn it is there, railway facilities for bearing away the finished product are plentiful, and where these three necessary elements are present, capital in time is sure to come, to be invested and to make this section of our State a great clay industrial center.

Potter's clay of excellent quality abounds near Bloomingdale and Annapolis, Parke County; Brazil and Clay City, Clay County; Huntingburg, Dubois County; Cannelton, Perry County; Logootee and Shoals, Martin County, and at numerous other points in the coal-bearing area of our State. Many of these deposits have been and are being put to practical use, but as yet no large potteries, similar to those at Zanesville and Akron, Ohio, have been erected in Indiana, though the facilities for raw material and fuel at some of the points above mentioned can not be excelled elsewhere in the United States.

Fire clays, suitable for making fire brick, saggers, bessemer converters, furnace linings, and many other refractory products, occur in quantity in the coal-bearing counties. One of the largest and purest deposits occurs near Montezuma, in Parke and Vermillion counties. Chemical analysis of this clay proved it to contain 98.24 per cent. of clay base and silica, and but 1.76 per cent. of fluxes. It has been in use for over twenty years in making refractory products.

Clays suitable for pressed front brick occur in many portions of the State. Different colors of these brick can be made by mixing the underclays of the coal seams with surface clays, shales, etc. One of the best clay deposits, not only for making pressed brick of different colors, but for making many other kinds of clay products, occurs at Mecca, Parke County, Indiana.* Another large deposit suitable for making the finest of red front brick is found in the outskirts of the town of Martinsville, Morgan County. Both of these deposits have railway facilities already in place, and at Mecca valuable coal mines are being operated on the land.

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*See twentieth report of this Department, page 53.

SANDS.

Sand suitable for glass making occurs in quantity near Pendleton, Madison County; Montpelier, Blackford County, and Lapel, Hamilton County. A large deposit has also been recently discovered near Coxville, Parke County, which is being rapidly developed. A fine grade of moulder's sand, suitable for foundry use, occurs near Centreton, Morgan County; Rockport, Spencer County, and Salem, Washington County, and the Hon L. U. Downey, of Gosport, has recently discovered a similar deposit of large extent near that town.

Sand suitable for builders' purposes and similar uses occurs in all parts of the State, one of the largest available deposits which has come to my notice being located one mile north of Mecca, Parke County. The deposit at this point is thirty-five feet thick and one-half mile long, and lies alongside a switch of the C. & I. C. Railway.

SOILS.

Among the most valuable natural resources of Indiana are her soils. More people are dependent upon them than upon all the rest of her resources and manufacturing establishments combined. The study of the origin, distribution and constituents of soils falls naturally to the Department of Geology, though many essays and valuable papers relating to their culture and fertilization appear in the Reports of the State Board of Agriculture.

The soils of Indiana may be roughly classified into three great groups, viz.: drift soils, residual soils and alluvial soils. The drift soils are found in the northern three-fourths of the State, are extremely varied in depth and character, and are formed of a mass of heterogeneous material which was brought to its present resting place by a great glacier or slowly moving sheet of ice which, thousands of years ago, covered the area mentioned.

The residual soils are found in the counties south of the southern limit of the glacier. They were formed for the most part in the place where they are now found by the decay of the underlying limestone or sandstone rocks. The variety of materials entering into their composition is therefore limited, and they are for that reason among the poorer soils of the State.

The alluvial soils are those of the river and creek bottoms throughout the State. Gentle rains and earth-born torrents, little trickling rills and strong streams are ever at work tearing down the soils and underlying clays from every slope and bearing them away to lower levels. The small water-formed trench of to-day next year becomes a chasm and ages hence a hollow, and the transported material is gradually deposited as alluvial soil over the so-called "bottom lands" which are annually overflowed.

In the production of any cereal nothing new is created, but forms of matter, already existing in the earth, air and water are utilized by the growing plant. Taking wheat for example, besides the carbon, hydrogen and oxygen, which make up the greater bulk of the straw and grain, and which are abundant enough in the air and water, potash, nitrogen, phosphoric acid, magnesia, lime, sulphur, chlorine and silicon are absolutely essential constituents. If any *one* of these is lacking in the soil, or is present in a form not available by the wheat roots, the plants will not flourish and the soil will be worthless for wheat production. Such a soil may, in most cases, be made to produce a crop of grain by adding to it the constituent which is lacking, but if this can not be done except at a prohibitory cost, or one at which more fertile ground can be procured, the soil may be regarded as "worn out" or barren.

The drift soils, which cover the northern and central portions of Indiana, derived, as they were, from various primary and igneous rocks in the far north—ground fine and thoroughly mixed, as they were, by the onward moving force of a mighty glacier—are usually rich in all the above named necessary constituents of plant food. Neither they nor the alluvial soils require a large annual outlay for artificial fertilizers as do the residual soils of southern Indiana, over which the drift of the glacial period did not extend.

Analyses of soils from every county, showing the proportions of phosphates, nitrates and other necessary elements of vegetation, should be made. From them the farmer could determine what constituent of his soil, if any, is deficient, and could supply the same in suitable quantities and in an available form. From them, also, it would be possible to specify the localities where the different staple crops could be most advantageously grown, instead of compelling the farmers to learn the peculiarities of their lands by experiments which necessarily consume time and exhaust the soil. Such a series of analyses, and an exhaustive report dealing with the origin, distribution and fertilization of our soils, can only be undertaken and carried to successful completion when the Legislature of our State becomes more generous in the sum allotted for the maintenance of the Department of Geology.

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The above is a brief résumé of the more important resources of Indiana. As already noted, these resources are being developed at the rate of nearly twenty millions of dollars yearly, yet much of the capital which is bringing about this development is owned by parties outside the State. They reap the benefits; they pocket the profits. The people of

Indiana, with hundreds of thousands of dollars of capital lying idle, are for the most part reluctant to invest in the resources of their State. They stand by and see our thickest coal veins, our greatest clay factories, our largest stone quarries, the majority of our oil wells, and the greater part of our natural gas property owned and operated by foreign capital.

A few millions of dollars are invested in developing these resources and pay taxes into our treasuries, but the profits, aggregating far greater sums, go into the coffers of non-resident owners. Were Indiana capital invested, both capital and profits would remain in the State, and the wealth upon which taxes are based would increase in much greater proportion.

In the clay industry, especially, should Indiana capital be invested, and the several millions of dollars now annually sent outside the State for clay products be kept within her bounds. With raw material and fuel both plentiful, home factories should be erected, should be protected, should be patronized, for in such a way only can the future wealth and welfare of the State be increased and plentiful labor be provided for her workingmen.

OTHER FEATURES OF THE REPORT.

Besides the features already mentioned, the present report contains a paper on "The Geology of Vigo County," by Dr. J. T. Scovell, of Terre Haute.

In this paper Dr. Scovell has given especial attention not only to the general geology of the county, but has treated fully its economic resources and archæology. The paper is accompanied by an excellent map of the county, showing the location of all the more important features mentioned in the text. Both paper and map are based on careful observations made during a residence of more than twenty years, so that the report is much more valuable and can be relied upon much more fully than if written by a non-resident assistant detailed for that purpose.

A paper upon "The Flora of Vigo County," based upon notes accumulated during a seven years' study of the plants of the county, was prepared by the writer, and is published in connection with Dr. Scovell's paper.

But little has heretofore been written concerning the caves of southern Indiana. These caves are numerous in the thick limestone formations of that section of the State, and form one of its natural features well worthy of special investigation by all who enjoy the study of Nature. A five weeks' trip, devoted to the exploration of a number of these caves, was made by the writer and a party of assistants in the summer of 1896, the main object in view being the collecting of underground specimens for the State Museum. Full notes relative to the origin, size, shape and fauna of each cave visited were taken and from these notes a paper entitled "Indiana Caves and Their Fauna" has been prepared, and forms a part of this report.

THE STATE MUSEUM.

To the State Museum connected with the Department of Geology many additions have been made during the past two years. Among these may be mentioned more than two hundred mounted birds and mammals, a large collection of birds' eggs, a case of clays and clay products, a case of cave specimens and a case of native woods, most of which are from Indiana.

The greater portion of the contents of the Museum have been rearranged on an accurate scientific basis and typewritten labels prepared therefor. This work has been done by myself and assistants during the winter months, after the completion of the annual report and before the beginning of the next season's field-work. A catalogue of the contents of the Museum has also been partially prepared and will be published as soon as the work is completed. It is my ambition to make the Museum a representative collection of Indiana geological and natural history specimens, where much may be learned of the forms of life inhabiting our State in the past, as well as those found therein at present. The Museum has already become a center of attraction to many people of the State who visit Indianapolis, and its educating effect can hardly be over-estimated. Many teachers bring their pupils in a body and spend a day or two in looking over its contents. All visitors are welcome—the open hours being from 9 A. M. to 4 P. M., except on Sundays and legal holidays.

OFFICE WORK.

More than two thousand letters relative to the resources of Indiana, were answered from the office of the Department in 1896. They came not only from citizens of Indiana, but from almost every State in the Union, and proved conclusively the need of a central bureau where such information can be obtained. Taking into consideration the vastness of the undeveloped resources of the State, and the fact that the Department of Geology is the only official source of information concerning them, it would seem that Indiana should not only maintain, but maintain liberally, that Department which has for its purpose the advertising of these resources to the other States and nations of the world. Omitting the soils and taking the estimate of $20,000,000, which is an extremely low one, as the annual value of the resources at present produced, the sum allotted to the Department for the years 1896–'97 was but thirty-five one-thousandths of one per cent. of that productive value. What business man would, for a moment, think of carrying on a successful business with so small a percentage spent for advertising? Yet the advertising at present done through its reports can but result in bringing into the State a vast amount of capital, the taxes on which will soon amount to a hundredfold more than the few thousand dollars now set apart for the annual maintenance of the Department of Geology and Natural Resources.

THE PETROLEUM INDUSTRY IN INDIANA.

BY W. S. BLATCHLEY.

CHAPTER I.

DEFINITION OF PETROLEUM—GEOGRAPHICAL DISTRIBUTION OF PETROLEUM—ORIGIN OF PETROLEUM—GEOLOGICAL DISTRIBUTION OF PETROLEUM—PHYSICAL AND CHEMICAL PROPERTIES OF INDIANA PETROLEUM.

The two resources of natural gas and petroleum have, within the past decade, added vastly to the wealth and population of the northern half of Indiana. The former was the first discovered, and millions of dollars have been invested in manufactories in the gas field, and thousands of people from other States and countries have flocked thereto, finding plentiful employment at good wages.

Following fast upon the development of the gas area came the discovery of petroleum in Wells and neighboring counties, and the sinking of bores for the "rock oil" so long stored in the porous reservoirs of the Trenton limestone has gradually developed into a notable industry in at least six counties of the State.

Although constant demands have been and are being made upon the State Geologist for literature and maps relative to the Indiana oil field, hitherto they could not be furnished because none had been prepared. The only paper published by the Department of Geology upon the subject was one of twenty pages in the report for 1891. It was written by A. C. Benedict, then an attache of the Department, and dealt more largely with the history of petroleum, and with areas in Indiana not now producing oil in commercial quantities, than with the present productive field.

In consideration of this lack of literature on the subject, and in accordance with the plan adopted by the present Geologist of taking up the chief resources of the State and treating each in detail, the present paper has been prepared. It is based upon a careful study of the field made by the Geologist in person during the months of June, September and October, 1896, and has been supplemented by notes and reports rereceived from different persons in the field up to January 1, 1897, so that it may be considered as fairly representative of the developments made to that date.

As one travels through the oil district of the State a sense of the greatness of the industry grows rapidly upon him. One might study it for years and yet not master its every intricacy. He finds a vast system of pumps, tubes and pipes drawing a stored liquid from the depths of the earth and transporting it hundreds of miles to distant refineries, there to be separated into parts, each of which serves as a basis for articles of manifold kinds for the use of man. Depending upon this industry are several thousand men—rig builders, drillers, tool dressers, pumpers, pipemen, gaugers, etc., each class performing a special duty and all working in harmony for the advancement of the common industry. Yet the resource itself is seldom seen, except where it overflows in waste, even by the army of workmen who are engaged in its production.

In a study of such resources as coal, clay, building stone, etc., one can see the strata *in situ*, note their arrangement, measure their thickness and study in detail their relation to their surroundings; but in an area covered so deeply with drift as is the oil field of Indiana, and where the resource in question is contained in a rock formation nowhere exposed to view within the State, the difficulties in the way of a proper presentation of the subject are many. The records of the formations passed through by the bores had to be obtained from drillers and operators, many of whom had little geological knowledge. Moreover, their records were scanty in detail, noting little else than the number of feet of drive pipe and casing used, the depth at which the Trenton rock was found, and the total depth of the bore. However, I found them at all times willing to place at my disposal such knowledge and records as they possessed, and to them I am indebted for such records as are included in the report. To Messrs. L. C. Davenport, of Bluffton; E. J. Little, of Van Buren; Benjamin Fulton, of Portland, and A. T. McDonald and W. S. Morton, of Montpelier, I am under special obligations for services rendered, both in the field and since my return therefrom.

DEFINITION OF PETROLEUM.

Various natural products, called bitumens, have been known to mankind for many centuries. These bitumens comprise a class of minerals, each member of which is made up largely of the nonmetallic elements,* carbon and hydrogen, so combined that the resulting compound will burn readily, with a bright flame and without leaving a residue.

Petroleum a Bitumen.—Like most other kinds of matter, the bitumens occur in three forms, namely, solids, liquids and gases. Each of these forms has many varieties, to which different names are given in different countries, but the typical representatives of each form are as follows:

Solid: Asphalt or Asphaltum.
Liquid: Petroleum.
Gaseous: Natural Gas.

Between these different forms of bitumen a close relationship exists. Especially is this true of petroleum and asphaltum, the one merging into the other through the intermediate varieties known as mineral tar, mineral pitch, etc. It is also well known that when petroleum is freely exposed to the atmosphere for a long time, it loses certain volatile constituents, and gradually passes into asphalt.

While natural gas seems more remotely related to petroleum, the two, in ages past, probably had a common origin. Marsh gas, or light carburetted hydrogen (CH_4) makes up more than ninety per cent. of natural gas. Petroleum, when destructively distilled, yields a large percentage of the inflammable marsh gas. Again, no geological formation is known to yield gas in large amount without in some portion of its area yielding oil as well. Taking these facts into consideration, and at the same time remembering that in nature each form of matter is constantly undergoing change, it is very likely that in the thousands of centuries which have elapsed since the petroleum was formed, much, if not all, of the natural gas has been derived from it by volatilization, or otherwise.

The word "petroleum," like "natural gas," relates to the origin rather than the composition of the substance. It is derived from two Latin words "*petra*," a rock, and "*oleum*," oil, and in many localities the name "rock oil" is given it.

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*An *element* is one of the seventy primary forms of matter which make up the universe. It is a substance which has never been separated into anything simpler. Two or more elements united together form a *compound*. There are millions of compounds, but only seventy elements. For example: Wood is a compound, which in the chemical laboratory can be separated into three substances, carbon, hydrogen and oxygen; but no man has as yet been able to separate carbon, hydrogen or oxygen into anything simpler than themselves. Hence, they are elements. The seventy elements bear the same relation to the compounds, as the twenty-six letters of the English language bear to its four hundred thousand words. Or, to state it still differently, the elements form the alphabet of the universe.

GEOGRAPHICAL DISTRIBUTION OF PETROLEUM.

¶ Contrary to common belief, petroleum is widely and abundantly distributed throughout the countries of the world; while its geological horizons include every known formation from the old Archæan rocks up to the later members of the Tertiary period.

New Zealand, Australia, Japan, China and India, all have large known deposits; those of Japan having been put to use for more than a thousand years.

Farther northwest, at Baku, in the Russian province of Apsheron, on the shores of the Caspian Sea, is the richest pool of petroleum known to man. The oil from this district has been used for 2,500 years, and as far back as the thirteenth century Marco Polo wrote of it as follows:

"On the confines toward Georgine there is a fountain from which oil springs in great abundance, inasmuch as a hundred ship-loads might be taken from it at one time. This oil is not good to use with food, but is good to burn, and is also used to anoint camels that have the mange. People come from vast distances to fetch it, for in all countries round there is no other oil."

The Apsheron peninsula proper has a known oil bearing area of 1,200 square miles though but seven square miles are at present developed. The oil is formed in loose sandstone or coarse sand beds of the Eocene age. Since 1875 a number of flowing wells or fountains have been drilled, the yield of some of which is given by Redwood as follows:*

One in 1875, 14,300 barrels daily.
One in 1876, 6,430 barrels daily for 3 months.
One in 1883, 13,700 barrels daily for 1 week.

On September 1, 1883, the famous "Droojba" fountain was drilled in at a depth of 574 feet, and commenced flowing at a rate of 40,000 to 50,000 barrels, valued at over $50,000, daily. This well has been graphically described as follows:

"The fountain was a splendid spectacle—it was the largest ever known in Baku. When the first outburst took place the oil had knocked off the roof and part of the sides of the derrick, but there was a beam left at the top against which the oil burst with a roar in its upward course, and which served in a measure to check its velocity. The derrick itself was seventy feet high, and the oil and the sand, after bursting through the roof and sides, flowed fully three times higher, forming a greyish-black fountain, the column clearly defined on the southern side but merging in a cloud of spray thirty yards broad on the other. A strong southerly wind enabled us to approach within a few yards of the crater on the former side, and to look down into the sandy basin formed round about the bottom of the derrick, where the oil was bubbling around the stock of the oil shoot like a geyser. The diameter of the tube up which the oil was rushing was ten inches. On issuing from this the fountain formed a clearly defined stem about eighteen inches thick, and shot up to the top of the derrick, where, in striking against the beam, which was already worn half through by the friction, it got broadened out a little. Thence continuing its course more than two hundred feet high, it curled over and fell in a dense cloud to the ground on the north side, forming a sand bank over which the olive-colored oil ran in innumerable channels toward the lakes of petroleum that had been formed on the surrounding estates. Now and again the sand flowing up with the oil would obstruct the pipe, or a stone would clog the course. Then the column would sink for a few seconds lower than two hundred feet, to rise directly afterward with a burst and a roar to three hundred. Some idea of the mass of matter thrown up from the well could be formed by a glance at the damage done on the southside in twenty-four hours—a vast shoal of sand having been formed, which had buried to the roof some magazines and shops, and had blocked to the height of six or seven feet all the neighboring derricks within a distance of fifty yards. Some of the sand and oil had been carried by the wind nearly one hundred yards from the fountain. Standing on the top of the sand shoal we could see where the oil, after flowing through a score of channels from the ooze, formed in the distance, on lower ground, a whole series of oil lakes, some broad enough and deep enough to float a boat in. Beyond this the oil could be seen flowing away in a broad channel towards the sea. The well was capped on the 29th of December, 1883, after giving an amount of oil estimated at 220,000 to 500,000 tons."*

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*Petroleum and its Products, 1896, 25.

> "The remarkable feature of this well was, that instead of making its owner a millionaire, as would have been the case in America, it both ruined him and broke the heart of the engineer who bored it. The reason was that the fountain belonged to a small Armenian company, which had enough ground for a well but not enough for large reservoirs. The oil flowed over neighboring properties, and was partially caught and sold by those on whose land it trespassed, and the quantity was so great as to reduce the price enormously, while at the same time the deluge of sand did so much damage in swamping the neighboring wells and houses that the amount of compensation claimed from the Droojba company far exceeded the value of the oil recovered by them.†"

The most productive well ever drilled, however, was about one-third of a mile from the Droojba, and began producing in March, 1893, at the rate of 120,000 barrels daily. It will be seen from the above extracts that the spouting wells of the Caspian far outstrip their American competitors in volume and energy.

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*Petroleum and its Products, 1896, 25.

†H. M. Cadell, Trans. Edinb. Geol. Soc., VII, 1894, 63.

Westward from Baku oil is found in numerous countries of continental Europe, the most important deposits being in Galicia, Roumania and Denmark.

In the New World deposits of petroleum are known in Mexico, Peru, Venezuela, Alaska, and Ontario, Canada; but its most important oil field occupies a broad zone about 750 miles in length, extending from New York State south and west through western Pennsylvania, West Virginia, Ohio and part of northern Indiana. Outside of this area the most important oil fields in the United States are near Los Angeles, California, where 1,200,000 barrels were produced in 1895; and in Colorado, which produced 530,000 barrels the same year. Small fields are also developed in Wyoming, Kansas, Kentucky and Tennessee.

The following table gives the production of petroleum in the United States from 1859 to 1895, inclusive, together with the average yearly price per barrel:

Production of Crude Petroleum in the United States from 1859 to 1895 (Barrels).

YEAR.	Pennsylvania and New York.	Ohio.	West Virginia.	Colorado.	California.	Indiana.	Kentucky and Tennessee.	Illinois.	Kansas.	Texas.	Missouri.	Indian Territory.	Wyoming.	Total United States.	Average Yearly Prices per Barrel.
1859 . . .	2 000	. . . .	. . . .	. . .	. . .	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	2.000	. . .
1860 . . .	500,000	. . . . . .	. . . . .	. . .	. . .	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	500,000	$9 59
1861 .	2,113,609	. . . . . .	. . . . .	. . . . .	. . .	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	2,113,609	49
1862 . . .	3,056,690	. . . . . .	. . . . .	. . . . .	. . .	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	a3,056,690	1 05
1863 . . .	2,611,309	. . . . . .	. . . . .	. . . . .	. . .	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	2,611,309	3 15
1864 .	2,116,109	. . . . . .	. . . . .	. . . . .	. . .	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	2,116,109	8 06
1865 . . .	2,497,700	. . . . . .	. . . . .	. . . . .	. . .	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	2,497,700	6 59
1866 . . .	3,597,700	. . . . . .	. . . . .	. . . . .	. . .	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	3,597,700	3 74
1867 . . .	3,347,300	. . . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	3,347,300	2 41
1868 . . .	3,646.117	. . . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	3.646,117	3 62½
1869 . . .	4,215,000	. . . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	4.215.000	5 63¾
1870 . . .	5,260,745	. . . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	5,260.745	3 84
1871 . . .	5,205,234	. . . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	5.205,234	4 34
1872 . . .	6,293.194	. . . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	6,293,194	3 63
1873 .	9.893.786	. . . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	9,893,786	1 87
1874 . . .	10,926,945	. . . . . .	. . . . .	. . . . .	. . . .	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	10.926.945	1 15
1875 .	8,787,514	b200,000	b3,000,000	. . . . .	b175,000	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	b12.162,514	1 36
1876 . . .	8.968,906	31,763	120,000	. . . . .	12,000	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	9,132,669	2 56½
1877 . .	13,135,475	29,888	172.000	. . . . .	13.000	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	13,350.363	2 42
1878 .	15,163,462	38.179	180,000	. . . . .	15,227	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	15.396,868	1 19
1879 . . .	19,685,176	29,112	180,000	. . . . .	19,858	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	19,914,146	85⅞
1880 . . .	26,027,631	38,940	179,000	. . . . .	40,552	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	26,286,123	94⅝
1881 . . .	27,376,509	33,867	151,000	. . . . .	99,862	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	27,661,238	85⅞
1882 . . .	30,053,500	39,761	128,000	. . . . .	128.636	. . . . .	c160,933	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	30,510,830	78⅜
1883 . . .	23,128,389	47,632	126,000	. . . . .	142,857	. . . . .	4,755	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	23,449,633	1 05⅞
1884 . . .	23,772,209	90,081	90,000	. . . . .	262,000	. . . . .	4,148	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	24,218.438	83¾
1885 .	20,776,041	650.000	91,000	. . . . .	325,000	. . . . .	5.164	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	21,847,205	87⅞
1886 . . .	25,798,000	1,782,970	102,000	. . . . .	377,145	. . . . .	4,726	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	28.064,841	71¼
1887 . . .	22,356,193	5.018,015	145,000	76,295	674,572	. . . . .	4,791	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	28,278,866	66⅝
1888 . . .	16,488,668	10,010,868	119,448	297,612	690,333	. . . . .	5,096	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	27,612,025	87⅝
1889 . .	21,487,435	12,471,466	544,113	316,476	303,220	33,375	5,400	1,460	500	48	20	. . . .	. . .	35.163.513	94⅛
1890 . . .	28,458,208	16,124,656	492,578	368,842	307,360	63,496	6,000	. . . .	1,200	54	278	. . . .	. . .	45,822,672	86¾
1891 . . .	33,009,236	17,740,301	2,406,218	665,482	323,600	136,634	9,000	. . . .	1,400	54	25	30	. . .	54,291,980	67
1892 . . .	28,422,377	16,362,921	3,810,086	824,000	385.049	698,068	6,500	. . . .	. . . .	45	10	80	. . .	50,509,136	55⅝
1893 . . .	20,314,513	16.249,769	8,445,412	594,390	470,179	2,335,293	3,000	. . . .	. . . .	50	50	10	. . . .	48,412,666	64
1894 . . .	19,019,990	16,792,154	8.587,624	515,746	705,969	3,688,666	1,500	300	40,000	60	8	130	2,369	49,344,516	72
1895 . . .	19,144,390	19,545,233	8,120,125	529,482	1,208,482	4,386,132	1,500	200	44,340	50	10	37	3,455	52,983,526	1 09
Total .	516,657,260	133,343,773	37,179,604	4,188,325	6,683,901	11,341,664	222,513	1,960	87,530	361	401	287	5,824	709,713,403	. . . .

a In addition to this amount it is estimated that for want of a market some 10,000,000 barrels ran to waste in and prior to 1862 from the Pennsylvania fields; also a large amount from West Virginia and Tennessee. *b* Including all production prior to 1876 in Ohio, West Virginia and California. *c* This includes all the petroleum produced in Kentucky and Tennessee prior to 1883.

THE ORIGIN OF PETROLEUM.

How and from what source did petroleum and natural gas originate? The answer to this question has been sought, especially in recent years, by the most eminent chemists and geologists of the world. Many laboratory experiments have been made with a view to answering it, and from the results thus obtained numerous theories have been advanced, but no one of them has, as yet, found universal acceptance. The more important of these theories will be taken up and briefly discussed in the present paper. For convenience they will be separated into two groups, viz.: *inorganic* and *organic* theories.

INORGANIC THEORIES.

While the theories which ascribe the origin of petroleum to inorganic objects have few adherents among the geologists and scientists of the present day, among the masses of the people who think of such subjects it is perhaps the prevailing opinion that in some mysterious manner oil and gas have been and are being formed in the depths of the earth by the action of water upon rocks or metals. Such an opinion probably had its origin in a theory advanced in 1866 by Berthelot, a distinguished French chemist. He expressed the view that the interior of the earth contains large quantities of the alkali metals, potassium and sodium, in a free or uncombined state, and that water, charged with carbonic acid, finds its way to these metals, and, assisted by the high temperature and great pressure necessarily existing at such depths, combines with them to form both liquid and gaseous bitumens.

Berthelot's Theory.

It is needless to say that such a theory finds little credence among scientists and others acquainted with the many conditions under which petroleum exists in the rocks of the earth. The theory is based wholly upon remote possibilities, and is incapable of the slightest verification by the geologist. Not a particle of evidence exists tending to prove that either sodium or potassium occurs uncombined in the interior of the earth. Even if they should so occur, neither of the two is a constituent of petroleum, and the latter, according to the theory, would have to be wholly formed from the water charged with carbonic acid, which, in itself, is impossible.

Another inorganic theory which has gained wide circulation is that of Mendeljeff, proposed in 1877. He refers to the great density of the earth and to the well-known presence of iron in meteorites and the solar system, as shown by the spectroscope.

Mendeljeff's Theory.

Assuming the commonly accepted theory of La Place, that the earth has been formed from incandescent matter thrown off from the sun, he asserts that, according to well-known physical laws, the vapors making up the incandescent matter arranged themselves according to their specific gravities, the heavier being nearer the center of the earth, and the lighter nearer its surface. In this manner *iron*, either pure or in the form of a carbide, was collected in large quantities at great depths in the earth. Afterwards, by internal forces, the cooler crust of the earth has been broken and allows the water which has collected thereon to run through the fissures to the hot masses of iron carbide. The iron forms an oxide with the oxygen of the water. The hydrogen of the water unites with the carbon from the iron to form a light hydrocarbon, which in time is condensed into the heavier petroleum. In this way he claims that not only the deposits of bitumens already existing have been formed but new ones are continually being formed at great depths in the earth and are gradually forced upward into cracks and fissures nearer its surface and there stored. As for the proofs of his theory, he asserts that the largest deposits of petroleum are found in the neighborhood of mountain ranges, where fissures leading to the depths of the earth are most likely to occur, and that he and other chemists have obtained petroleum-like hydrocarbons by the action of boiling water or dilute hydrochloric acid upon spiegeleisen (carbide of iron and manganese).

The theory of Mendeljeff, like that of Berthelot, has few facts to bear it out. In America, at least, every field in which oil has been found controverts its leading assumptions. The larger oil fields of this country are *not* found along mountain ranges, but over level areas. There are within their bounds no fissures or cracks leading to the inner depths of the earth. The oil is found in pores of minute size between the grains of sandstone or limestone rock in which it occurs, and not in fissures and rents of the rock. Again, there is not a particle of known evidence tending to prove the presence of iron carbide in quantity at great depths in the earth; and even though a few of the simpler members of the series of hydrocarbons to which petroleum belongs have been formed artificially in the chemical laboratory from inorganic substances, all attempts to thus form such complex compounds, as is petroleum itself, have proven fruitless.

Such theories as those of Berthelot and Mendeljeff are, to say the least, not only crude and unscientific, but are productive of much harm, in that they tend to cause the masses to believe that natural gas and petroleum are being formed as fast as they are used. Such a belief is responsible for much of the reckless waste which has taken place in the gas fields of Indiana in the past; a waste which has already brought the stored supply down close to the limit at which the natural rock pressure of the gas is overcome by salt water.

ORGANIC THEORIES.

Among geologists and scientists in general it is now commonly believed that petroleum has been derived from the decomposition of animal or vegetable bodies, or both. Many laboratory experiments and facts observed in nature tend to confirm this belief. For example, when the body of an animal or plant is distilled in a closed retort or undergoes decay in the absence of air certain gaseous and liquid products are always derived. Again, oily water frequently exudes from peat mosses, and marsh gas, already mentioned as being the chief constituent of natural gas, bubbles up from every stagnant pool which contains rotting vegetable or animal matter at its bottom. There is, therefore, no need of far-fetched chemical theories to explain what is more or less a matter of common experience.

Secondary Decomposition Theory.

However, two distinct views prevail among geologists as to the manner in which the decomposition has been brought about. One of these views, known as the *secondary* decomposition theory, was first set forth by Prof. John S. Newberry, formerly State Geologist of Ohio. He claims that the great beds of bituminous shales, such as the Huron, Genesee and Utica shales, have been the chief sources of petroleum—that the animal and plant remains in those beds have undergone a kind of distillation or secondary decomposition, resulting in petroleum, which, by hydrostatic pressure, has been carried to the rock strata in which it is now found. As a proof of this theory, Professor Newberry says:

> "We have in the Huron shale a vast repository of solid hydrocarbonaceous matter, which may be made to yield 10 to 20 gallons of oil to the ton by artificial distillation. Like all other organic matter, this is constantly undergoing *spontaneous distillation*, except where hermetically sealed deep under rock and water. This results in the formation of oil and gas closely resembling those which we make artificially from the same substance, the manufactured differing from the natural products only because we can not imitate accurately the processes of nature.
>
> "*Second.* A line of oil and gas springs marks the outcrop of the Huron shale from New York to Tennessee. The rock itself is frequently found saturated with petroleum, and the overlying strata, if porous, are sure to be more or less impregnated with it.
>
> "*Third.* The wells on Oil Creek penetrate the strata immediately overlying the Huron shale, and the oil is obtained from the fissured and porous sheets of sandstone of the Portage and Chemung groups, which lie just above the Huron, and offer convenient reservoirs for the oil it furnishes." *

Of Prof. Newberry's theory it may be said that, while it is true that the shales contain oil in large quantities, which may be separated from them by distillation, there is no direct proof that this oil is wholly indigenous to the shale, *i. e.*, derived from the remains of organic life which was buried in it. Few, if any, traces of animal life are found in shales. In some places, however, remains of plant life are fairly abundant,* but not enough so to have furnished the source for as large an amount of oil as the shales contain. Yet, at the time the shales were deposited, algæ and the simpler forms of plant life, whose decomposition would leave no residue or fossils, were undoubtedly abundant and may have supplied a large proportion of the petroleum which the shales contain.

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* Geol. of Ohio, I, 158.

On the other hand, all shale beds are sedimentary in their origin, being composed of particles of clay (an inorganic material) which have been carried long distances and redeposited in water. Now it is well known that clay has a particular affinity for oily matter. Oily substances floating in muddy water have been found to attach themselves to suspended particles of clay and sink to the bottom and produce there a stratum rich in oil, which in time would be compressed by the newer overlying strata into shale. Much of the petroleum of the shale may thus have been derived from organic matter undergoing decomposition in *other* and remote strata.

At the time that the "secondary decomposition theory" of Dr. Newberry was published, the large deposits of oil in the Trenton limestone rocks of Ohio and Indiana were unknown. His theory was based largely upon the Pennsylvania fields, and seems more clearly than any other to explain the origin of the petroleum there found. The Pennsylvania oil occurs in a series of sandstone strata which contain few, if any, organic remains, and could not, therefore, have furnished the original source of the oil. These sandstone strata overlie the bituminous shales, and, from their porous nature, have served as reservoirs into which the oil, oozing from the shale, has passed and accumulated in large quantities.

Primary Decomposition Theory.

The second organic theory, known as the "primary decomposition theory," was first promulgated by Dr. T. Sterry Hunt about 1862, and, better than any other, accounts for the origin of the oil in the Trenton limestone rocks wherever found. Dr. Hunt asserted that petroleum has been formed from the remains of animals or plants in the rock strata *now* yielding the oil, the decomposition having taken place under such conditions that the organism passed directly into petroleum which has since remained in the rocks where it was formed.

Among the proofs of his theory, Dr. Hunt stated that in some cases petroleum is found filling the cavities of large fossil shells (Orthoceratites) in the Trenton limestone. "From some specimens nearly a pint of petroleum has been obtained." Again he cited the fact that a stratum of Niagara limestone near Chicago is so filled with petroleum that blocks of it, used in building, were discolored by the exudations, which, mingled with dirt, formed a tarry coating upon the exposed surfaces; and adds, "With such sources ready formed in the earth's crust, it seems to me, to say the least, unphilosophical to search elsewhere for the origin of petroleum, and to suppose it to be derived, by some unexplained process, from rocks which are destitute of the substance."

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*Notably in the Genesee shale at New Albany, Ind., where many remains of fucoids and allied plants have been recently discovered by Mr. Hans Duden.

Dr. Hunt also stated that one of the principal proofs of the truth of his theory lay in the statement of Mr. G. P. Wall, who, in 1860, published a report on the Asphalt Lake of Trinidad,* in which the following passage occurs:

"When *in situ*, it (the asphalt) is confined to particular strata which were originally shales containing a certain proportion of vegetable *debris. The organic matter has undergone a special mineralization, producing bituminous in place of ordinary anthraciferous substances. This operation is not attributable to heat, nor to the nature of distillation, but is due to chemical reaction at the ordinary temperature and under the normal conditions of the climate.* The proofs that this is the true mode of the generation of the asphalt repose not only on the partial manner in which it is distributed in the strata, but also on numerous specimens of the vegetable matter in process of transformation, and with the organic structure more or less obliterated. After the removal by solution of the bituminous material under the microscope, a remarkable alteration and corrosion of the vegetable cells becomes apparent, which is not presented in any other form of the mineralization of wood. Sometimes the emission is in the form of a dense, oily liquid, from which the volatile elements gradually evaporate, leaving a solid residue."

The theory of Dr. Hunt was made known about 1862, long before oil was discovered in the limestone rocks of Ohio and Indiana. The facts gathered and observations made in the Trenton-limestone field of these States have furnished much evidence in support of his theory; and it is now commonly believed by scientists that the oil found in limestone has been produced in the rock by the direct decomposition of organisms originally inhabiting the water in which the rock was deposited. Moreover, it is believed that for the most part those organisms were animals, since the limestone oil possesses more sulphur and nitrogen, is of a darker color, higher specific gravity, and has a more rank and disagreeable odor than the "shale oil" produced in Pennsylvania, which probably owes its origin to the decomposition of plants in the manner set forth in the theory of Dr. Newberry, as given above.

Coal Theory.

The theory that petroleum had its origin in coal, or that the two are closely related, is held by many people. While it is true that both coal and oil are undoubtedly the remains of past existing organisms, the main petroleum field of Indiana is one hundred and fifty miles distant from the main coal area. Moreover, the Trenton rock containing the oil belongs to an entirely different formation, and was in existence thousands of years before the plants from which the coal is derived flourished. Even where the Trenton rock directly underlies the coal strata there are several impervious strata between them which neither gas nor oil could penetrate. These facts show conclusively that, in Indiana at least, there has been no connection whatever between the origin of the coal and petroleum.

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*Quarterly Journal Geol. Soc., XVI, 1862, 467.

Life of the Trenton Period.

It is a well known geological fact that most if not all limestones owe their origin to the presence of minute organisms in the water in which the limestones were formed. The animals from whose remains the oil of the Trenton limestone was, for the most part, derived, were probably very low forms—the polyps and bryozoans of the ancient Silurian seas. In untold numbers they existed, and the carbonate of lime which makes up eighty per cent. of the unmodified Trenton rock, is largely the remains of their secretions and incrustations.* Associated with these lower forms were myriads of higher ones—crinoids, brachiopods, trilobites, gastropods and even fishes; remains of these earliest known vertebrates having been discovered in the Trenton of Colorado by Walcott, in 1891.†

The presence of such swarms of animal life made necessary the existence of an abundance of plants, since the plant must ever precede the animal and gather for the latter the energy, and form for it the food—the living protoplasm—necessary to its existence. These plants were mostly marine algæ or seaweeds and fucoids, though doubtless many other forms existed of which no remains have been preserved in the rocks of that age.

Formation of the Trenton Limestone.

The Trenton limestones were evidently formed in rather clear water, at moderate depths. Near the bottoms of these shallow seas great beds of calcareous sediment were gradually collected, and were swept to and fro by the tides and currents. Rivers from the older Cambrian rocks brought down their eroded particles and added to the thickness of the ocean floor. Within these beds of sediment both plants and animals found a grave—their bodies in vast numbers being buried beneath the slowly accumulating deposits of centuries. Once buried in such deposits, they did not decay, as do animals on land, because by the waters above and the calcareous ooze around them, they were shut off from free oxygen, which is the chief agent in decay. Gradually this ooze or fine sediment was, by the agency of the sea water, cemented and consolidated into limestone. In time the waters containing these beds of limestone, with their enclosed accumulations of undecayed plants and animals, became turbid, and, instead of calcareous sediment, deposited mud and clayey sediment in thick beds on top of the limestone strata. These deposits of mud and silt were afterward, by later deposits, compressed into the fine-grained, impervious Utica shale, which thus effectually sealed the Trenton limestones and so retained within them the oil and gas derived from their enclosed organic remains. This oil and gas was probably not formed in a short time, but is the result of a slow decomposition, carried on through hundreds and thousands of centuries. The primary product of such decomposition was probably a light oil, which, in the course of ages, has, by volatilization, yielded the gas, and has itself been condensed into the heavier petroleum.

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* *Vide* Ulrich, Rep. on L. Sil. Bry. Minnesota (Vol. III, Geol. and Nat. Hist. Surv. Minn., 1893, 96.

† Bull. Geol. Soc. III, 1892, 153.

Not only Trenton limestones, but every other limestone, as well as most shales, have in the past produced petroleum in greater or less quantities. Distributed in minute proportions through the substances of the rocks, it easily escapes notice, but when intelligently looked for its presence is revealed, and, though the percentage is small, the aggregate is often vast. If, for example, a stratum carries but one-tenth of 1 per cent. of petroleum and is 500 feet in thickness, it contains more than 2,500,000 barrels to the square mile. Indeed, so common is the occurrence of petroleum in stratified rocks that wherever a close-grained shale occurs there is almost always a small accumulation of oil directly underneath it. The same thing is found when an impervious stratum of any other composition than shale occurs in the geological series.

In concluding these remarks on the origin of petroleum, I can not do better than to add as a summary the following opinions of Dr. Edward Orton, which, slightly modified, are as follows:

1. Petroleum is derived from organic matter.
2. Petroleum of the Pennsylvania type is derived from the organic matter of bituminous shales, and is probably of vegetable origin.
3. Petroleum of the Ohio-Indiana type is derived from limestones, and is probably of animal origin.
4. Petroleum has been produced at normal rock temperature, and is not a product of destructive distillation of bituminous shales.
5. The stock of petroleum in the rocks is already practically complete.*

GEOLOGICAL DISTRIBUTION OF PETROLEUM.

If petroleum has been thus generally formed throughout the Trenton limestone, why do not all parts of that geological formation yield it in somewhat equal amounts? Why is it that a bore that pierces the Trenton in one locality is a "dry hole," while another, but a short distance away, results in a "hundred barrel" well? The answer to such questions lies in the fact that the formation of large accumulations of oil depends as much upon the presence of suitable strata to receive and retain them as upon an adequate source of supply. In the minutely diffused state in which the oil is originally formed it is wholly without value. Like all other forms of mineral wealth, it must be concentrated into reservoirs, the so-called "pools" of the oil fields, before it can be utilized by man. The conditions necessary to these accumulations are (1) a porous stratum of rock to serve as a reservoir; (2) an impervious cover above the reservoir; (3) an arched or anticlinal structure of the rock in which the reservoir is located; (4) a pressure behind the oil to force it into the reservoir. Each of these necessary conditions will now be briefly considered.

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*Report on the Occurrence of Petroleum, Natural Gas and Asphalt Rock in Western Kentucky, 1891, 60.

The rock formations which best furnish the necessary porosity for the accumulation of oil are (a) sandstones; (b) conglomerates, and (c) limestones which have undergone a certain chemical change since their formation.

The Porous Reservoir.

In the case of the sandstones and conglomerates a natural porosity exists between the particles composing the rocks. The greater the degree of porosity, the greater the amount of oil contained in the reservoir, or "pool." In most, if not all cases, the oil in sandstone reservoirs has been derived from the underlying strata, which are usually fossiliferous and highly compacted shales.

The Trenton rock, when first formed, was a true limestone or calcium carbonate ($CaCO_3$), in some places very pure (94 to 98 per cent. carbonate of lime); in others, more or less mixed with silicious and other impurities.

In time, as a result of the oscillations ever taking place in the sea level, certain large areas of the Trenton limestone became raised into great, shallow basins or lagoons, partially or almost wholly shut off from the main ocean. In these basins the sea waters were in an unusually briny condition, owing to large quantities of salts of magnesium which they held in solution. These magnesium salts, especially the chlorides, in the course of time, acted upon the *purer* areas of calcium carbonate, one-half of the calcium being removed by the chlorine and replaced by magnesium, as shown in the equation ($2CaCO_3 + MgCl_2 = CaMg2CO_3 + CaCl_2$), the change resulting in dolomite or calcium-magnesium carbonate ($CaMg2CO_3$). This change took place only in the purer Trenton limestone after the Trenton rock had been formed and consolidated, and before the Utica shale had been deposited over it.

As a result of the change into dolomite, the rock became reduced in bulk about one-eighth of one per cent., and at the same time more or less porous, the porosity resulting from the fact that the new crystals of dolomite never entirely filled the spaces from which the crystals of lime had been removed.* *The larger areas of the Trenton limestone were either too*

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*In the change into dolomite small cavities in great numbers were left between the interlocking points of the replacing crystals, equaling, or even greatly exceeding, the spaces between grains of sand or pebbles.—*Orton, Geol. Survey of Ohio, 1890, 69.*

impure to admit of the change into dolomite, or the conditions of sea level were never such that the change could take place in them; hence, they are found destitute of either oil or gas. Even in rich oil fields the porous dolomite has only been formed in a small proportion of the thickness of the Trenton rock. Usually two or more "pay-streaks" or porous strata are found in the upper fifty feet of the Trenton. The upper one of these has a thickness of three to ten, or sometimes fifteen feet, and usually occurs within twenty feet of the top of the Trenton. If the level of the Trenton is low at the point where the bore is put down, the upper streak is often lacking. The second porous stratum, usually the most productive, lies about fifteen to twenty feet below the first and is separated from it by a bed of unchanged, non-porous limestone. This alternation of dolomite and limestone strata is probably due to alternations in the sea levels at the time the limestone was undergoing the change into dolomite. Wherever the Trenton limestone assumes its normal character and ceases to be dolomitic, it ceases also to be oil-bearing. The change from an area containing porous rock into one wholly lacking it, is often abrupt. It is only the former which contains the oil, and there is no known method, except by drilling, of determining where the porous rock occurs.

The Impervious Cover.

In order to properly retain the accumulated petroleum the porous rock must be entirely covered with an impervious stratum; *i. e.*, one through which neither the oil nor its volatile constituents will pass or can be forced by the enormous pressure behind it. Such a cover is usually a fine-grained shale, and wherever such a stratum covers a porous rock, petroleum in greater or less quantities is usually found. In the Indiana oil field the Trenton rock is covered by an average thickness of 250 feet of that dark brown, close-grained deposit known as the Utica shale, which possesses every quality of a typical impervious cover. The driller recognizes this stratum as soon as he strikes it, by its color, its comparative freedom from fossils, and the ease with which it is drilled and mixed with water. No free oil is found in the Utica shale, though by distilling portions of it an amount equal to three per cent.* of the shale has been obtained.

The Anticlinal Structure.

Owing to the contractile movements of the cooling crust of the earth, it has become in many places creased or raised into folds, which often extend for long distances with great regularity. Sometimes these contractions have been violent, resulting in a pushing upwards or protrusion of the crust into chains of mountains. More often they have resulted in the formation of a series of broad, low curves, whose arches are known as anticlines and whose troughs are called synclines. These changes in level took place in an early part of the earth's history and affected mainly the older formations. Since then other formations have been deposited, filling up the depressions and leveling the surface, so that the existence of these wavelike folds in deep-lying strata is revealed only by the bore or shaft sunk to them.

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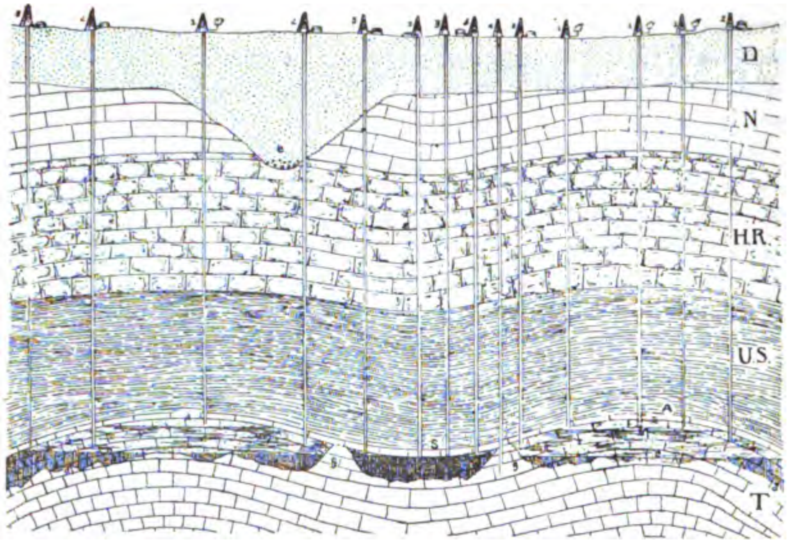
*Dana, Manual of Geology, 4th Ed., 522.

The records of the numerous bores put down in recent years for oil and gas in Ohio and Indiana show that the surface area of the Trenton rock is not, as many people think, a level plane, but that numerous rather broad arches and troughs, or anticlines and synclines, exist in it. Experience has proven that the anticlines in the Trenton are important factors in the geological distribution and accumulation of oil and gas Where the anticlines occur the wells drilled along their crests yield at first gas and after a time oil. Those drilled into the troughs yield only salt water, while in those put down in the intermediate territory, or slope of the anticline, there is most probability of finding oil. The explanation is obvious. The original brine in the Trenton, being heavier than either gas or oil, sank to the lowest position it could reach; the lighter oil assumed an intermediate position, and the still lighter gas was forced or found its way upward to the crown of the arch, where it has remained under great pressure, imprisoned by the impervious stratum of Utica shale covering the porous reservoir.

In the Indiana oil field the production of a new well can usually be foretold by the depth at which the top of the Trenton rock is found. If it is from five to ten feet higher than the average in the nearby productive wells, the chances are that it will yield much gas and little oil. On the other hand, if the Trenton is struck ten to fifteen feet lower than the average, the bore has pierced a trough or syncline, and a salt water well usually results. Sometimes, however, there are apparent exceptions. Of two wells in which the Trenton is found at the same depth, one will be a "gusher," and the other, but a short distance away, a "dry hole." The only explanation which can be given in such a case is that the latter has pierced a close-grained or non-porous area of the Trenton, through which no fluid can find its way. Again, there may be secondary or subsidiary flexures or anticlines which influence the distribution of the oil in local areas. Finally, it may be said that the anticlinal structure has, by numerous tests and observations, been proven to be of the greatest importance in the accumulation of oil in all the great productive fields at present known to man.

The following illustration will, perhaps, lead to a better understanding of the facts mentioned in the last few pages:



D., Drift. N., Niagara limestone. H. R., Hudson River limestone. U. S., Utica shale. T., Trenton limestone. A., anticline. S., syncline. a to b, gas bearing stratum. b to c, oil bearing stratum. c to d, water bearing stratum of porous rock. e, preglacial channel through Niagara limestone. f, non-porous Trenton limestone.

Wells, No. 1 produce gas; Nos. 2, oil; Nos. 3, salt water; No 4, dry hole; Nos. 5, oil and salt water.

Whenever the drill pierces a stratum of porous rock containing oil, the latter is pushed upward by the so-called "rock-pressure" behind it. Sometimes this pressure is so great that when the oil stratum is reached the boring tools are expelled from the drill hole, and the oil escapes in a fountain, rising high above the derrick, much of it being lost before the flow can be controlled.

The Rock Pressure.

In most instances, even if the well proves to be one of small production, the oil is forced upward several hundred feet in the drill hole. This rock pressure has in the past eventually had much to do with the accumulation of oil in the porous reservoirs, and it will, therefore, be briefly considered in this connection.

Several theories have been proposed as to the cause of the pressure, but the one which is upheld by the most facts, especially in the Trenton limestone field of Ohio and Indiana, is that it is nothing more nor less than water pressure, as in artesian wells, the water entering the porous stratum at some point where the latter outcrops and so forming the "head" or "source." Dr. Orton has calculated the pressure which should be found in certain wells at certain depths, if produced by a head of water equal to the depth of the well below tide level, and has found a remarkable agreement with the actually-measured pressures in many wells of Ohio. He concludes, therefore, that "the rock pressure of

Trenton limestone gas or oil is due to a salt water column measured from about 600 feet above tide to the level of the porous stratum holding the gas or oil.*

The outcrops of the porous Trenton rock which allow the water to enter and so serve as a head, are probably located on the shores of Lakes Superior and Huron at approximately the same elevation as that which the salt water reaches in the oil wells.

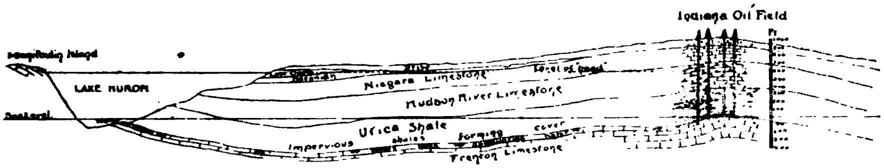


FIGURE ILLUSTRATING ARTESIAN ACTION IN INDIANA OIL FIELD.

The Trenton limestone, being porous, and covered by the impervious Utica shale, serves as a channel for water. This water enters the Trenton at its outcrops along the margins of Lake Huron. In the Indiana oil field the water is, therefore, under a "head" equal to the difference in depth between the Trenton at that point and the level of Lake Huron. It is this "head" which gives the pressure to the oil and gas in Indiana.

The water when it first passed into the Trenton rock gathered the particles of disseminated oil upon its surface and pushed them ahead into the higher and limited areas in which the great accumulations are now found. It has since remained below these accumulations, and so served as a seal on the lower side in like manner as has the Utica shale on the upper. When the driller passes below the second "pay-streak" or layer of porous rock, he always finds the salt water, which rises in the well several hundred feet, and sometimes flows out at the surface. As the supply of oil is diminished the water takes its place in the pores which the former occupied. "Salt water makes the normal and well-nigh universal contents of the porous rocks. The rare exceptions, in localities favored by the accidents of structure, are the stocks of gas and oil, which in reality are very scanty, but which, by comparison with each other, we sometimes call great. Their total volume is insignificant when compared with the other elements with which they are associated. We have no reason to believe that all the accumulations of petroleum contained in the crust of the globe would exceed a few cubic miles in volume, but the salt water contained there would make a sea."—(*Orton.*)

If the above theory is the correct one, and all the facts tend to prove that it is beyond a reasonable doubt, it will be seen that the rock pressure is no indication of either abundance of the oil or permanence of its supply. The porous rock holds a limited amount; the salt water is behind this amount ever pressing it forward into the vent furnished by the drill hole. When the supply is exhausted, as it naturally will be in time, there is no source from which it can be renewed. The salt water will rise and occupy the pores which formerly held the oil, and it will come to stay.

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*Geol. Surv. Ohio, 1890, 102.

THE PHYSICAL AND CHEMICAL PROPERTIES OF INDIANA PETROLEUM.

The crude petroleum obtained in Indiana is a brownish black liquid with a specific gravity of about .853.* It possesses a rank and disagreeable odor, due to the sulphur compounds which it contains. The elements composing it are carbon, hydrogen, oxygen, nitrogen and sulphur, the last two being present in small amounts. The first three are so combined that the petroleum burns readily, and yields but a small amount of residue.

Two samples of crude petroleum, one furnished by Mr. E. J. Little, from the Van Buren, Grant County, field, and the other obtained by Dr. W. A. Noyes, from one of the wells at Terre Haute, Vigo County, were examined by Dr. Noyes, who reported on them as follows:

	Terre Haute.				Van Buren.			
	Per Cent.	Specific Gravity.	Degrees, Beaume.	Flashing Point.	Per Cent.	Specific Gravity.	Degrees, Beaume.	Flashing Point.
Original oil.....	....	0.879	30°	......	...	0.853	35°	......
Below 150° C ..	...	....	...	......	7.2	0.719	....	Below 20°C
150°–200° C.....	12.0	0.793	48°	38° C	10.2	0.759	56°	Below 20°C
200°–250° C.....	14.0	0.825	41°	65° C	10.2	0.799	47°	60°C
250°–300° C....	13.6	0.847	36.5°	85° C	12.2	0.826	41°	82°C
300°–350° C.....	14.8	0.867	32.5°	97° C	14.8	0.844	37°	96°C
350°–390° C..	40.6	0.879	30°	45° C	41.8	0.860	34°	35°C
Total distillate.	95.0	..	...	..	96.4	...	...	......
Residue by weight				6.2 per cent.				4.5 per cent.
Sulphur				.72 per cent.				.83 per cent.

"The oils were distilled rather slowly from flasks with the thermometer in the vapor only. A thermometer filled with nitrogen and graduated to 460° C. was used.

"The oils appear to be quite similar in general character, but there is less of the low boiling products in the Terre Haute oil, and the specific gravity of the oil and of the various distillates is higher. The portion of the Terre Haute oil boiling at 350°—390° deposits considerable amounts of solid paraffines at 15° C. The low flashing point of the high boiling oil must be due to a partial 'cracking' of the oil. From the results, I calculate the following percentage of naphtha and kerosene contained in the petroleums:

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*By specific gravity is meant its weight as compared with an exactly equal volume of distilled water, the temperature of the two being the same.

	Terre Haute.	Van Buren.
Naphtha below specific gravity 0.73	None.	10%
Kerosene between specific gravity 0.73—0.83	30%	33%

The Terre Haute oil is derived from a different formation than the Trenton.* It is darker colored, more ill-smelling (though, according to the report of Dr. Noyes, the percentage of sulphur is less) and of a greater density and weight than that from Van Buren. At the present time it is used in the manufacture of illuminating gas and as a fuel.

Almost all of the petroleum from the main Indiana field is transported by pipe line to the refinery at Whiting, Indiana, and there manufactured into various commercial products. Within recent years a process has been put into use by which the injurious sulphur compounds are removed by means of iron filings, while the oil is in a state of vapor, so that kerosene almost equal in quality to that derived from the Pennsylvania oil is now obtained from the once despised and little-valued Trenton limestone oil of the Lima-Indiana field.

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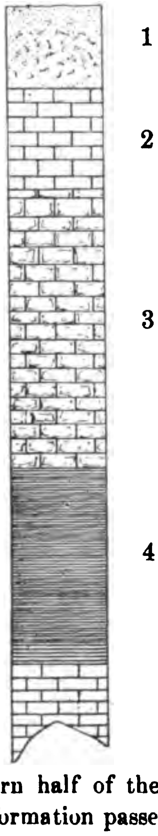
*See Report on Geology of Vigo County, by Dr. J. T. Scovell, in this volume.

CHAPTER II.

THE INDIANA OIL FIELD.

Area.

The area of Indiana at present producing petroleum in commercial quantities occupies a portion of six counties northeast of the center of the State, viz.: Adams, Jay, Blackford, Wells, Grant and Huntington. As shown on the accompanying map it comprises about 400 square miles, being included within a strip of territory thirty-three miles long and twelve miles wide, extending from a short distance northeast of Bryant, Jay County, to near Landessville, Grant County. This territory comprises all or a part of each of the following civil townships: Wabash and Hartford, Adams County; Bear Creek, Jackson and Penn, Jay County; Harrison and Washington, Blackford County; Nottingham, Chester and Jackson, Wells County; Van Buren and Washington, Grant County; Salamonie and Jefferson, Huntington County. Outside of this field, as limited on the map, no oil is at present being produced in Indiana, except at Terre Haute, Vigo County, where three wells have been yielding since 1889.



Topography.

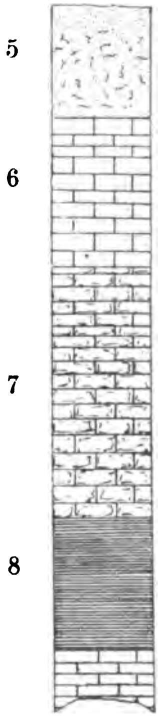
The surface of the area now yielding oil was originally one great plain, with only occasional small undulations to break its monotony. This has been eroded in many places by the streams, which in the past have been much larger than at present. Wherever bluffs or hills are found they are but the results of such erosion. But few outcrops of rock occur within the oil field and they are found only along the streams where the water has eroded deep channels through the drift and bowlder clay, everywhere covering the oil territory from a depth of 50 to 250 feet. These outcrops belong to the Niagara group of the Upper Silurian period.

The formations passed through by the drill in all parts of the field before the Trenton limestone is reached are, therefore, as follows: Drift; Niagara limestone; Hudson River limestone; Utica shale. In the eastern half of the field an average section showing the thickness of each formation passed through would be about as follows:

1.	Drift	125 feet.
2.	Niagara limestone	150 feet.
3.	Hudson River limestone	425 feet.
4.	Utica shale	300 feet.

In the western half the average shows:

5.	Drift	175 feet.
6.	Niagara limestone	225 feet.
7.	Hudson River limestone	380 feet.
8.	Utica shale	200 feet.



The average depth at which the Trenton rock is found below the surface is very close to 1,000 feet, and the first stratum of porous rock or first "pay streak" is usually between seventeen and thirty feet below the surface of the Trenton, the upper crust of the Trenton being a very pure, hard, non-porous limestone, often containing as high as 95 per cent. of carbonate of lime.

The Indiana oil field is, without doubt, a westward extension of the Ohio field, though as yet the connecting area between the two has not been located. From the easternmost Indiana wells, at Bryant, it is but seventeen miles in a southeasterly direction to the wells at Fort Recovery, Ohio; twenty-three miles due east to those at Selma, Ohio, and twenty miles northeast to those at Wiltshire, Ohio.

Salt Water.

Throughout the Indiana field what is known as the drive pipe, an iron tube 8 to 10 inches in diameter, is forced down through the drift and boulder clay to the solid Niagara limestone. In this stone is always found more or less salt water; hence, a casing tube 5⅝ or 6¼ inches in diameter is used through the full thickness of the Niagara to shut out the water. Below the Niagara no water is usually found until the Trenton rock is struck. If the well has been located over a syncline, or trough, in the Trenton, salt water is apt to be found before the drilling has proceeded very far into that formation, and a well yielding only salt water usually results. If gas or oil is found the salt water is usually below them, at a depth of sixty or more feet in the Trenton; and the operator is usually careful to see that the drilling is stopped before that depth is reached. In some cases, however, the water and oil are found together in the same stratum. Some of the best wells in the Indiana field are big salt water wells, pumping from 150 to 700, or even more, barrels of salt water and 40 to 150 barrels of oil daily, after having been in operation for a year or more. It costs much more to operate such a well, as it has to be pumped with a beam and, therefore, requires a separate power. The salt water seems to keep the pores of the oil rock free from paraffine and other materials which have a tendency to clog them up, and a well producing four or five barrels of water a day in connection with the oil, is preferred by many operators to one that produces oil alone.

WELLS COUNTY.

Wells County, in which petroleum in paying quantities was first discovered, comprises an area of 372 square miles, 106 of which are included within the known productive oil territory. The surface of the county is level or gently rolling. The average altitude above sea level is about 850 feet. The Wabash River flows diagonally across the county, entering it on the eastern side, a little below the center, and flowing in a northwesterly direction. The Salamonie flows across the southwestern corner in the same direction, and these streams with their numerous smaller tributaries furnish an abundance of running water and in most townships an ample system of drainage.

The soils of Wells County are above the average in fertility. Made up of a mixture of ingredients derived from the decaying rocks of the far north, ground fine and thoroughly mixed as they were by the mighty glaciers which brought them to their present resting places, they contain all the necessary constituents for the growth of the cereal crops, and, therefore, do not require an annual outlay for artificial fertilizers. Corn and wheat yield enormously in the southern and western portions of the county, and the majority of the farmers were in good circumstances long before the drill revealed that another resource which had been stored since the old Silurian days, lay far beneath the surface of the soil they tilled.

Two railways, the Toledo, St. Louis & Kansas City ("Clover Leaf") and the Ft. Wayne, Cincinnati & Louisville, pass entirely through the county, while the Chicago & Erie touches its northern border; so that the means for transportation of the resources of the county are excellent.

Three townships of Wells County lie largely or wholly within the oil field proper, and in a fourth, Liberty Township, two or three productive wells have been put down. Of these

NOTTINGHAM TOWNSHIP

is by far the largest producer, some of the richest pools in the State having been found within its bounds. This township comprises forty-eight square miles, being eight miles long by six wide; two tiers of sections on the west side of Congressional township 25 north, range 13 east, having been added to township 25 north, range 12 east, in its formation.

The first well in the township and the second in the present field was put down on the Nathan Cory farm in the southeastern quarter of section 28 (25 north, 12 east), by Mr. E. J. Little, in June, 1891. The following record of this well has been kindly furnished me by Mr. Little:

Drive pipe	68 feet.
Casing	306 feet.
Trenton struck at	1,026 feet.
Gas found	1,036 feet.
Oil found	1,038 feet.
Total depth	1,051 feet.

It began to yield at the rate of 250 barrels daily. This was kept up for some time, but gradually fell, until in June, 1896, it was yielding but three barrels daily.

The boring of this well and its success led immediately to the leasing of the surrounding territory, and the rapid opening of the rich deposits in the southern half of the township. The field took on a new lease of life, and there has been no time since that drilling for oil has not been going on in Indiana.

Of the forty-eight sections in Nottingham Township ten at present produce no oil These are sections 5, 6, 7 and 8, in township 25 north, range 13 east, and sections 1, 2, 3, 10, 11 and 12 in township 25 north, range 12 east. No drilling has been done in these sections except in the southeast quarters of sections 3, 7 and 10, in each of which one dry hole has been put down

In the northwest corner of the township no drilling has been done in the north half of sections 4, 5 and 6, nor in the southwest quarters of sections 4 and 6. The southeast quarters of each of these sections have light wells on them, while the southwest quarter of section 5 contains one dry hole.

Sections 7 and 8 and the northeast and southwest quarters of section 9 are proving to be good territory. In section 8 Sharpe & Hittman have nine wells which in June, 1896, were producing fifty barrels daily. One of these started in June, 1895, at two hundred and fifty barrels, averaged one hundred and fifty barrels for fifteen days, but by June, 1896, was down to ten barrels. In these wells the Trenton rock was struck at a depth of 998 to 1,003 feet, and the first porous stratum at seven feet lower. The northwest and southeast quarters of section 9 yield little oil, several dry holes having been drilled on them. A pumping station of the Buckeye Pipe Line is located at Ruth, in the southwest quarter of this section. Two twelve-thousand barrel tanks are located at the station, and much of the oil produced in Nottingham and Chester Townships is forced from there through a four-inch main to Preble, Ohio, where it enters the main leading to the refinery at Whiting, Indiana.

Beginning on the east side of the next lower tier of sections, we find that section 17 (25 N. 13 E.) produces some oil in its northern half, while its southern half may be classed as good territory. Section 18 has scarcely been tested, and its southern half may in time become productive. The north halves of sections 13 and 14, and the northeast quarter of section 15 (township 25 north, range 12 east) are as yet undrilled. The south halves of 13 and 15 are good producers, while that of 14 has so far proven light. Sections 16, 17 and 18 comprise good producing territory, section 17 being one of the best in the entire field. In the "Abshire" pool, in the south half of section 16 and the north half of section 21, forty wells have been put down by the American Oil Company. The first one was drilled in June, 1893, and the others at intervals of about one month thereafter. The average production of the forty in September, 1896, was ten barrels each. The Trenton rock was found at an average depth of 1,001 feet.

In the next tier of sections, Nos. 19, 20, 21, 22, 23 and 24 (25 north, 12 east) have all yielded good wells, those of the south half, section 23, being the best. Pumping stations of the Buckeye Pipe Line are located in the southwest quarter, section 19, and the southeast quarter, section 23. Two dry holes had been put down in the southeast quarter, section 24, prior to 1896, and the greater portion of the quarter section thereby condemned. W. H. Dye, of Indianapolis, re-leased the territory, and in the autumn of that year put down two wells, the first of which started at 200 and the second at fifty barrels, thus furnishing proof that one or two dry holes on a quarter section are no evidence of its non-productiveness.

Sections 19, 20, 29 and 30 (township 25 north, range 13 east) have proven good territory, except the northeast quarter of 19, where two dry holes have been drilled. On the Peter Schott farm, in the southeast quarter of 19, a well was drilled thirty feet into the Trenton in 1894, and yielded nothing but salt water. It was abandoned and partly filled with sand. In May, 1896, a new derrick was put up, the sand and water pumped out, and the bore put down twenty feet deeper and then shot. A hundred-barrel well resulted, which is still keeping up a good yield.

Of the two remaining sections in 25 north, 13 east, No. 32 has a fair yield, while 31 ranks among the best in the township.

The Cudahy Bros., of Chicago, have recently erected in the northwest quarter of section 32 a pumping station and a 38,000-barrel tank. The Northern Indiana Oil Company, which operates a large amount of territory in this portion of the Indiana field, is controlled by them, and the oil will from January 1, 1897, be pumped directly to Chicago through some large mains put down in 1896.

The farm of Geo. W. Brookhart, occupying the northeast quarter of section 31, has been one of the best producers in the Indiana field. The first well was drilled in May, 1893, the second in June, and the third and fourth in the last half of the same year. Five additional wells were put down in 1894, and four in 1895. Up to September 1, 1896, Mr. Brookhart's one-eighth royalty had amounted to over $12,800 for the thirteen wells, so that more than $100,000 worth of oil had been produced from the 160 acres. The depth at which the Trenton limestone was found ranged between 997 and 1,011 feet for the thirteen wells.

The No. 11 well on this farm was thought at first to be a dry hole. "If it had been outside of the farm," said Mr. Brookhart, "it would have been abandoned." The company finally concluded to shoot it with 200 quarts of nitroglycerine. After the shot it yielded only salt water for a week. Then it began yielding oil at the rate of thirty barrels a day. This rapidly increased, and when the well was fifty-six days old it had produced fifty-four tanks of oil, proving itself by far the best well on the farm. In September, 1896, it was yielding forty barrels of oil and 125 barrels of water a day. Like other large water wells, it has to be pumped alone; whereas the remaining twelve wells, together with fourteen on adjoining farms which are operated by the same company, are pumped by one power. The Geo. Updegraff farm and the Wolff farm, in the quarter section just south of that of Brookhart, have yielded proportionally as much as the Brookhart farm.

Sections 25 to 32, inclusive (township 25 north, range 12 east), have proven good oil territory. On the Harshman and Templin farms, in the northwest quarter of section 26, Davenport, Simmons & Co. put down several wells in 1894 and 1895. The average record of these wells, as given me by Mr. L. C. Davenport, was as follows:

Drift	108 feet.
Niagara limestone	164 feet.
Hudson River limestone	443 feet.
Utica shale	300 feet.
Trenton struck at	1,015 feet.
First oil struck at	1,028 feet.

In the best well on the quarter section the Trenton was found at a depth of 1,010 feet; the well starting at 160 barrels per day in March, 1894, and being down to ten barrels in June, 1896. In the poorest well the Trenton was found at 1,023 feet. The well started at twenty barrels and was down to three in a short time. Eighteen thousand dollars was spent on the lease. Oil equal to that amount in value was produced, and the property was then sold for $18,000. Since then five bores have been put down on the quarter section, four of which have proven dry holes.

As an example of what may be done with a fairly good producing small lease, when properly managed, we may mention that of the 40-acre farm of Margaret Yeager, in the northeast quarter, section 28, operated by L. C. Davenport, of Bluffton. It has on it four wells, the first of which was put down in 1893, and the last in 1894. The average of the well records, as kept by Mr. Davenport, are as follows:

Drive pipe	54 feet.
Casing	294 feet.
Trenton struck at	1,031 feet.
Oil found at	1,046 feet.
Total depth	1,073 feet.

Average initial product, 55 barrels.

Up to September, 1896, $5,500 had been expended on the lease; $6,000 worth of oil had been sold; and the property was valued at $4,000, based on the market price of oil, 57 cents per barrel. The four wells were then yielding about 18 barrels of oil daily. The only expense for operating was the salary of the pumper, $45 a month; gas and oil, yielded by the wells, being used as fuel.

In the northwest quarter section 29, the Schooley farm has proven excellent territory, more than $80,000 worth of oil having been produced by the 11 wells drilled on it.

Sections 33 and 34 are rather lighter in their yield than those of the remaining sections of the lower tier; while sections 35 and 36 (25 north, 12 east) are both counted as good territory. On the J. Brown farm, in the northwest quarter, section 36, the average record of four wells is as follows:

Drive pipe	128 feet.
Casing set at	264 feet.
Trenton struck at	1,010 feet.
Oil found at	1,025 feet.
Total depth	1,060 feet.

Average initial output, 80 barrels.
Average output in June, 1896, 6 barrels.

An average of the township will probably show 280 feet as the amount of casing put in, and 1,020 feet as the depth at which Trenton is found.

Up to the present, Nottingham Township has probably yielded more oil than any other two townships in the Indiana field. The wells, while not starting in with as large a flow as in some other parts of the field, have held up better. But few, even of the older wells, have as yet been abandoned. While most of the territory has been tested, there is undoubtedly some which has been condemned by one or two dry holes, which will yet be found to be productive. Examples of such territory have already been noted as occurring on the H. Brooks farm in section 24 and the Peter Schott farm in section 19 (25 north, 13 east).

Again, some of the sections in the northern half of the township, as yet undrilled, will probably be found to yield oil in fair amounts, while in much of the territory now producing there is still room for additional wells, so that the output of oil from the township bids fair to be a good one for a number of years to come.

CHESTER TOWNSHIP

comprises thirty-six square miles, corresponding in its civil boundaries to the Congressional township, 25 north, range 11 east. Although a number of good wells have been found within its bounds, the township as a whole contains much light oil territory and has proven a disappointment to those interested in the development of the Indiana field.

The first well to show oil in any quantities in the State was put down by the Northern Indiana Oil Co., on the D. A. Bryson farm, near Keystone (southwest quarter of section 26), in June, 1890. The Trenton limestone was found at a depth of 986 feet, oil at 1,012 feet and salt water at 1,023 feet. The well flowed naturally sixty barrels the first twenty-four hours, but in three months had declined to twenty-five barrels. It was then shot with forty quarts of nitroglycerine, and the flow increased to 100 barrels, but in nine months was down once more to twenty-five barrels. Once again it was shot, this time with 100 quarts, and the flow again increased to 125 barrels, but in two weeks was down to seventy barrels; in three months, to fifty barrels; and in 1896, when six years old, was still yielding eight barrels daily.

Several other wells were put down in 1890 by the Northern Indiana Co. in the vicinity of the first one, but, as none of them showed oil in paying quantities, the company gave up the idea of getting oil there, and no further drilling was done in Wells County until Mr. E. J. Little put down the Cory well in Nottingham Township.

Taking up the sections of the township in detail, we find that Nos. 1 to 4, inclusive, have had but one well drilled in them. This was on the southeast quarter of section 3, and came in in July, 1896, as a very light producer. The Trenton rock was struck at a depth of 998 feet.

Section 5 contains three very light wells on its south half, and one dry hole on its northwest quarter, where the rock was found low—1,020 feet.

In the north half of section 6 a number of wells were put down in 1896, but the yield was light. The Trenton was found almost level, ranging from 1,011 to 1,016 feet. The south half of section 6 and sections 7 and 8, comprise good territory. It was in this locality that one of the principal extensions of the Indiana field was made in 1896, the line of the known producing territory being extended south and east of Mt. Zion, through sections 7 and 8. A number of the wells put down in these sections started out at 100 to 250 barrels daily.

Sections 9, 10, 11 and 12 have practically no production. Dry holes have been put down in the northwest and southeast quarters of section 9, the southwest quarter of section 11, and the northeast quarter of section 12 The remaining parts of the sections have not been tested, except the northeast quarter of section 11 and the southeast quarter of section 12, where one or two light wells are located.

A light production only has so far been obtained in sections 13, 14, 15 and 16. On the John Kennedy farm in the northwest quarter of section 16, A. L. Sharpe drilled in a well in July, 1896, which produced much gas, the Trenton being found at 984 feet, and a small amount of oil. Gas was first struck at 12 feet in the Trenton and oil at 27 feet. Three-fourths of a mile west, on the T. J. Callahan farm (northwest quarter of section 16) the Trenton was found to be 44 feet lower down, and no gas, oil or water was found until a depth of 1,051 feet was reached where "Blue Lick" water occurred. Between the two wells above mentioned, a bore on the farm of John McKey (northeast quarter of section 16) developed the Trenton at 1,014 feet, and a good production of oil. Such facts are strong proofs of the truth of the anticlinal structure of the Trenton having much to do with the distribution of the petroleum; the gas on the Kennedy farm being found in the crest of an anticline; the water on the Callahan farm in a syncline, and the oil on the McKey farm in intermediate territory.*

Sections 17 and 18 may be classed as good territory, the south half of section 17 being lighter than the north half

Of the next lower tier of sections, Nos. 19 to 22, inclusive, are light producers, the Trenton being found rather low. On the William Bennett farm in the northwest quarter of section 23 are a number of fairly good wells, and from there eastward through section 24 the Trenton rises and the production becomes better. The east half of section 24, and sections 25 and 26 may be classed as good producing territory, while Nos. 27 to 34, inclusive, are light, the four in the southwest corner of the township, viz., 29, 30, 31 and 32 being especially so. No drilling has, however, been done in section 28. In the south half of section 34 the Trenton is found 1,000 to 1,005 feet. Nearer Montpelier, in the township south, it rises to 970 feet, and the bores show much gas and a better production of oil.

Coming back to the southeast corner, we find sections 35 and 36 to be like the ones above them—good producers. These four sections evidently form a natural portion of an area of rich territory found to the eastward in Nottingham Township, and to the south and southeast in the corners of Harrison Township, Blackford County, and Penn Township, Jay County.

On the eighty-acre farm of Jane Howard, in the northeast quarter of the northeast quarter, section 36, seven wells were put down in the spring of 1896 by F. E. Alexander In six of them the Trenton rock was found at a depth of 1,024 feet, and in the seventh at 1,039 feet, the oil being found at seventeen to twenty feet lower in each case. All were productive, the initial output ranging from one hundred and fifty down to thirty barrels. In three weeks the one hundred and fifty barrel well was down to thirty barrels, while the thirty barrel well, when six weeks old, was still yielding eighteen barrels. A dry hole was put down on the farm immediately west, the Trenton being struck at 1,024 feet.

From what has been written concerning the production in Chester Township, it will be seen that the southeastern and northwestern corners only can be classed as good territory, the remainder having, as yet, shown a small production. A large portion of the southern half of the township seems to have the surface of the Trenton in a syncline which gradually rises to the westward, resulting in some good producing territory in the southern half of Jackson Township.

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*See page 43.

JACKSON TOWNSHIP

contains thirty-six square miles, and corresponds to the Congressional township (25 north, range 10 east).

Of this area about ten square miles may be classed as good oil producing territory. The remainder has, up to the present, yielded but little oil.

In the northeast corner, sections 1, 2, 12 and 13, and the north half of 11 seem to form the western half of what may be termed the Mt. Zion pool, inasmuch as they have proven themselves highly productive. Section 1 has probably produced more oil than any other section in the township.

On the G. W. Huffman farm, in the west half of the section, eleven wells were put down in 1894–5, in which the Trenton rock was found between 997 and 1,003 feet. For the month of May, 1896, the wells yielded 3,354 barrels, and for June 3,018 barrels, an average of ten barrels each daily.

No drilling has been done in sections 3 to 7, inclusive, except in the northeast quarter of 3 and the south half of 4, where some fairly productive wells have been put down. Section 8 has one dry hole in the northwest quarter, the remainder being untested. In section 9 two holes were put down in the south half in which a show of oil was found, but not enough, the operators thought, to warrant the expense of shooting the wells. The northwest quarter of the section contains fair and the northeast quarter good producing wells. The west half of section 10 contains some light wells, the east half being undrilled. A pumping station of the Buckeye Pipe Line is located on the northeast quarter of this section.

The south half of 11 and the east half of 14 include light producing territory, being seemingly on the southwestern edge of the Mt. Zion pool.

The west half of 14 and the north half of 15 are undrilled, while in the south half of 15 three bores have been put down, which resulted in a dry hole, a salt water well and a heavy gas well, the last two showing oil in small quantities.

A dry hole in the southwest quarter of 16, and one in the northwest quarter of 17, are the results of the only bores in those sections. Section 18 has had two wells put down on the east half which were so light that they are no longer pumping. The west half, and section 19 except the southwest quarter, are undrilled. On that quarter section several fair producing wells are located.

Section 20 has had several very light wells drilled upon it. On the Mercer farm, in the east half of the southeast quarter, the No. 1 bore put down by W. B. Little & Co. showed the following section:

Drift	121 feet.
Niagara limestone	259 feet.
Hudson River limestone	287 feet.
Utica shale	300 feet.
Trenton found at	967 feet.
Total depth	1,025 feet.

Result, dry hole.

Twelve hundred feet east a gas well was put down in 1891, which is now pumping about six barrels of oil daily, the supply of gas having gradually dwindled to practically nothing.

Section 21 and the southwest quarter of section 22 contain a number of fair producing wells. The Mercer No. 2, put down by W. B. Little, in the north half of the southwest quarter of section 21, in May, 1895, has the following record:

Drift	231 feet.
Niagara limestone	154 feet.
Hudson River limestone	296 feet.
Utica shale	300 feet.
Trenton found at	981 feet.
Total depth	1,020 feet.

Average initial product, 75 barrels.
Daily product in June, 1896, 8 barrels.

The great discrepancy in the relative thickness of the drift and Niagara in this bore and Mercer No. 1, suggests the presence of a preglacial channel in the Niagara, at the point where No. 2 was put down. In the north half of 22 and in section 23 a number of holes have been put down, but the yield of oil has been very light. Section 24 is undrilled, except in the northeast quarter, where a few light wells are found.

The sections of the next tier, 25 to 30 inclusive, are all light producers, except Nos. 27 and 28, which may be classed as good. The south half of 30 has not, as yet, been tested.

In the lower tier no drilling has been done in 31. The south half of 32 has a few light wells, and the north half two bores which yielded oil for a while, but are no longer pumped. Farther east the production becomes much better, and sections 33, 34 and 35 each have a number of good wells, while 36 is less productive. On the Byall farm in the southeast quarter of 34 is a large salt water well, which is also noted for its production of oil. It was finished in March, 1892, and in September, 1896, when four and one-half years old, was producing forty barrels of oil and 700 barrels of water daily. Two similar wells are located on the T. J. Banter farm in the southwest quarter of section 35. One of them, finished in June, 1895, was producing forty barrels of oil and 1,000 barrels of water in September, 1896. The other, finished a month later, yielded 210 barrels of oil and no water for several days before shooting. In a short time it began yielding water, and in September, 1896, was producing thirty barrels of oil and 500 of water daily. In such instances, it is believed that the water flows or is forced through the porous stratum and brings in with it oil from other territory.

While on the map the whole of Jackson Township is included in the productive area of the Indiana field, the good production, it will be seen, has been in spots, with much intervening territory, either undrilled or with a very light yield. In the center of the township, as well as in its northwestern fourth, there is much territory which has been condemned by dry holes, which, with a fair test, might prove productive. It is the writer's opinion, based on a careful study of the Indiana field, that there are greater chances of striking oil in the undrilled portions of such a township as Jackson, which lies within the limits of known productive territory, than by "wild catting," outside of such limits.

LIBERTY TOWNSHIP (26 NORTH, 11 EAST)

lies north of Chester Township, and east of Salamonie Township, Huntington County. But little drilling has as yet been done within its bounds. A bore in section 22 resulted in a salt water well A dry hole was put down in the southeast quarter section 34; and, in 1896, two light producing wells and one dry hole in the south half of section 31. One of the wells, located on the William Dalby farm, had an initial product of 50 barrels. The Trenton is found comparatively low in the section, being struck at a depth of 1,023 feet. A number of good wells have been drilled immediately west in sections 25 and 36, Salamonie Township, where the Trenton occurs between 990 and 1,000 feet.

* * *

Outside of the productive area shown on the map oil has been found at one or two other localities in Wells County, but not in paying quantities. At Kingsland, Jefferson Township, in the southwest quarter, section 33 (28 north, 12 east), Judge E. R. Wilson put down a well in 1890 for gas. It yielded but a small amount of gas and six barrels of oil daily. The well was capped in and 800 feet east a second bore was put down seventy-three feet into the Trenton, without finding either water, gas or oil.

Two bores were put down in Lancaster Township in 1894 by W. B. Little, one of which contained a small amount of oil. It was located on the east half section 11 (27 north, 12 east) and showed the following section:

Drift	80 feet.
Niagara	420 feet.
Hudson River limestone	300 feet.
Utica shale	347 feet.
Trenton at	1,147 feet.
Showing of oil at	1,168 feet.
Blue Lick (sulphur) water	1,187 feet.
Total depth	1,200 feet.

The second bore in section 1 (27 north, 12 east) found Trenton at 1,120 feet, and produced a small flow of gas.

ADAMS COUNTY.

This county lies east of Wells County and is bordered on the east by the Ohio State line. It is twenty-four miles in length from north to south and fourteen miles in breadth, comprising, therefore, an area of 336 square miles. Like Wells County, the surface is comparatively level, but well drained by the St. Mary's and its tributaries in the northern half and the Wabash and its tributaries in the south. The soil is rather more retentive of moisture than that of Wells County, but the materials composing it are essentially the same, and its fertility, where properly drained, has proven excellent.

Three railways pass through the county, the G. R. & I. from north to south, and the T., St. L. & K. C. and Chicago & Erie from east to west; Decatur, the flourishing county seat, being a junction point of the three.

Petroleum has so far been found in paying quantities only in the two townships of Hartford and Wabash, in the southwestern part of the county.

HARTFORD TOWNSHIP

comprises an area of only twenty-four square miles, the two western tiers of the Congressional township (25 north, range 13 east) being included in the civil township of Nottingham, Wells County. Of this area about one half is at present producing oil in paying quantities.

The first productive well in Adams County was put down by the Bolds Brothers on the George Shoemaker farm, east half of northeast quarter of section 26 (25 north, 13 east), in February, 1892. It started at 110 barrels a day and proved an incentive to much drilling in the neighborhood. The second well on the same farm was drilled in May, 1893, with an initial production of 100 barrels, and the third in July, 1892, started at sixty barrels. The lease was then sold for $8,000, much less than its actual value.

The most northern production in Hartford Township, at the present time, is in section 13, where there are several light producing wells.

Bores have been put down in sections 2, 4, 10, 11, 14, 15, 16 and 21, all of which resulted in dry holes or salt water wells.

Some good producing wells are found in the southeast quarter of section 22, but the remaining portions of the section have been condemned by bores resulting in salt water, or nothing. Sections 23 and 24 both comprise good territory; the former has one dry hole near its center, but several wells starting at 150 to 180 barrels have been located within its bounds. The southeast quarter of 24 has in the past yielded much gas, but has recently changed into productive oil territory.

The remaining sections of the township are all noted as good producers. On the C. Herschey farm, in the northeast quarter section 25, thirteen wells have been bored, the average depth of the Trenton being 1,004 feet, and the average initial production one hundred barrels. On the J. A. Martin farm in the southwest quarter of the same section, the record of a well put down in 1892 is as follows:

Drive pipe	110 feet.
Casing	230 feet.
Trenton struck at	996 feet.

Initial production, 150 barrels.
Production in October, 1896, 2 barrels.

On the northeast quarter of section 28 the drift was found to be fifty-seven feet thick, the Niagara 173 feet thick, and the Trenton at a depth of 1,002 feet. A number of the first wells in this portion of the township were drilled only about twenty feet into the Trenton, and so missed the second porous stratum, which lies deeper. The yield of oil from them has been much less on this account than what it otherwise would have been.

In section 33 the Trenton lies at about 1,003 feet below the surface. In section 34 a bore put down in 1893, and resulting in a dry hole, condemned 320 acres of land belonging to Joseph Watson. In 1895 it was re-leased, and has resulted in one of the most productive farms in the township.

In the south halves of sections 35 and 36 the Niagara limestone seems to have been cut out by spurs or tributaries of a great preglacial river, which will be mentioned more fully hereafter. As a result 350 to 400 feet of drive pipe must be used, and the expense of drilling is thereby much increased.

In the area of Hartford township in which oil has been found, the initial production has been above the average for the Indiana field, and the wells have held up better than those in the western part of that field. The large number of dry holes and salt water wells already down in the north part of the township are a strong proof that the northern boundary of the productive area has been practically determined, and that but few, if any, good wells will be found outside of the line shown on the map.

WABASH TOWNSHIP.

But four square miles of this township have up to the present yielded oil in commercial quantities. They comprise sections 18, 19, 30 and 31 along the western edge.

Along the northern border of section 18, Jones, Good & Co. have five light producing wells, the first of which was put down in 1892. Each of the five had a good initial production, but it gradually dwindled until in November, 1896, the total yield was but about ten barrels a day. The south half of section 18 and the north half of 19 have each been tested by several bores, which yielded salt water and but little oil.

The south half of 19 and the west half of 30 have each a number of good wells located on them. On the I. Wheeler farm, in the northeast quarter of 30, the Trenton was found at 1,030 feet and a dry hole resulted. On the J. Bucher farm, in the southwest quarter of the same section, two wells were put down in 1896, which started at 150 and 120 barrels respectively. In these the Trenton was found at 1,012 feet.

The wells on section 31 have been light producers. The drift is here found 400 feet deep, as also in the northwest quarter of the northwest quarter of section 32, where a single light well has been bored.

Wells in which more or less oil was found have been put down in Adams County at several points outside of the present producing area. In Wabash Township, on the southeast quarter of section 10, the Standard Oil Co., in 1893, drilled a well which started at fifty barrels. Much of the surrounding territory was immediately leased and a pipe line laid to the well mentioned, but the production rapidly dwindled and no further developments were made.

In the outskirts of Geneva, in the northeast quarter of the northeast quarter of section 29 (25 north, 14 east), a bore resulted in salt water with a showing of oil. The drift was here found to be 400 feet thick. A two barrel well was also developed in the northwest quarter of section 28.

In the south halves of sections 31 and 32 (township 26 north, range 15 east), Blue Creek Township, several bores have been put down. One, by the Superior Oil Co., resulted in a fifteen barrel well, which will still yield five barrels daily. The others were dry holes or salt water wells, which stopped further operations. The Trenton is here found at a depth of 1,092 feet, while seventy-seven feet of drive pipe and 300 feet of casing are necessary.

These isolated wells go to prove that oil occurs in the Trenton of the southeast corner of Adams County. There is little doubt, as already mentioned, but that the Indiana field is connected with that of Ohio by a strip of territory in southeastern Adams and northeastern Jay—the limits of which have not as yet been defined by the drill.

JAY COUNTY

comprises an area of 387 square miles, lying south of Adams and the eastern half of Wells counties and west of Mercer and Darke counties, Ohio. The surface of the county is gently rolling or nearly level, and the soil of most portions proves very fertile where properly drained and tilled. The Salamonie River flows through the county from southeast to northwest and drains its western and southern halves. The Wabash River touches its northeastern corner and through its tributaries drains the townships of Wabash, Bear Creek and Jackson.

The G. R. & I. Railway, passing north and south through the center of the county, crosses the L. E. & W. main line, running east and west, at Portland, the county seat. The P., C. & St. L. crosses the southwest corner of the county, passing through the thriving towns of Dunkirk and Redkey, so that the facilities of transportation in all directions are excellent.

In the Indiana field, Jay County ranks next to Wells as a producer of petroleum. The area at present productive of oil in commercial quantities lies for the most part west of the G. R. & I. Railway, in the northern tier of townships, though a few light wells are producing east of that line.

BEAR CREEK TOWNSHIP (24 NORTH, 14 EAST).

Of the thirty-six square miles embraced in the civil township of Bear Creek seven produce oil in sufficient quantities to pay for operating the wells. Those seven are sections 6, 7, 8, 9, 16, 17 and 18.

The west half of section 6 contains some good wells. On the farm of Dr. C. S. Arthur, in the northwest quarter, two bores struck the Trenton at 1,002 feet, one yielding 280 barrels the first day, the other being a dry hole.

The east half of the section is untested, except the extreme southeast corner, where a dry hole has prevented the drilling of adjacent territory in section 5. Section 7, and the southwest quarter of section 8 may also be called good territory. Bolds Bros., in 1892, held leases on 480 acres in section 7, and put down a bore which developed a dry hole. They gave up the leases, and the territory was re-leased and a second dry hole put down. Again abandoned, Bold Bros. took it up a second time and developed sixteen producing wells, which were yielding 110 barrels daily in 1896, when the property was sold for $30,000 to the Warren Oil Company. An average section of these wells shows:

Drive pipe	75 feet.
Casing	235 feet.
Trenton at	993 feet.

East of the G. R. & I. Railway, and northeast of Bryant, thirteen bores were put down in 1896, in sections 9, 10, 15 and 16 The first one, in the south half of section 9, started in June with a yield of 125 barrels, but by October had dropped to four barrels daily. The large initial product of this well caused the drilling of the remaining twelve, five of which were dry holes, and the remainder only light producers. The one farthest northeast in the northeast quarter of section 10 was yielding ten barrels a day when the engine was moved and the well plugged. Dry holes have been bored in the northwest quarter of section 14 and the southeast quarter of 15. In the north half of section 16 three light wells are located, while the south half is undrilled.

The north halves of sections 17 and 18 contain good wells; the south half of 17 being undrilled, and that of 18 having three bores each with a showing of oil, but not enough to pay for pumping.

In addition to those mentioned, bores have been put down in the township as follows: Two gas wells in section 19; two wells with a showing of oil, and one dry hole, in the northwest quarter of 31; one dry hole in the southeast quarter of 24. While the results of the developments so far made in Bear Creek Township have not been flattering, there is little doubt but that some good wells will yet be found in the undrilled territory of the two northern tiers of sections.

JACKSON TOWNSHIP (24 NORTH, 13 EAST.)

While the north half of this township has proven above the average for the Indiana field, the south half has as yet yielded little oil, and that in isolated pools.

Many more wells would have been put down in the north half had it not been for the deep drives necessary in what is known as the Loblolly. This name is given to a low, marshy tract of territory occupying the larger portion of the two northern tiers of sections in the township. A number of small lakes, very narrow and deep, were formerly scattered throughout its area, while the greater portion, not occupied by the lakes, was covered with water during a part of the year. Much of this territory has in recent years been reclaimed by drainage, and the soil proves to be among the richest in the county.

Since the discovery of oil in Indiana numerous bores have brought to light the remarkable fact that the Niagara limestone, which underlies the drift in all other portions of the field, is entirely lacking in the greater part of the area known as the Loblolly; and that the drift, instead of ranging from 50 to 175 feet in depth, as elsewhere, is here from 250 to 420 feet, and in a few instances, even 520 feet deep.

This phenomenon is without doubt due to the presence of a preglacial channel, which was eroded through the Niagara limestone, then the surface rock, by a large river which flowed in a southwesterly direction through the townships of Wabash, Adams County; Jackson and Penn, Jay County, and Harrison and Washington, Blackford County, its course, but not always its limits, having been traced by the bores put down in recent years.

This stream was probably the outlet of the melting waters of a great glacier which occupied a region far to the northeast. These waters flowing for centuries over the Niagara limestone gradually wore a channel through its entire thickness in the region now known as the Loblolly. Afterward the glacier itself moved slowly over the region, grooving and planing the surface of the solid rocks, strewing for hundreds of miles in its track beds of clay and sand and gravel, thereby filling up the channels of its ancient outlets and so hiding all knowledge of their course and depth, until man, seeking with steel drill for a hidden resource, discovers the absence of the eroded rock and reasons out the cause thereof.

The Loblolly district simply embraces a portion of the old bed that was deeper than the rest. The drift deposited in it being so much thicker than over the surrounding area of Niagara rock, and having no solid support near the surface, as did the latter, settled to such an extent that its surface was a few feet lower, and over this lower portion the surface waters collected. Wherever the Niagara has been thus eroded the cost of putting down a well through the deep drift is much greater, being seventy-five cents to one dollar a foot, as against forty-five to fifty cents in other places.

The northernmost tier of sections in Jackson Township, Nos. 1 to 6, inclusive, have all proved highly productive of oil. In the northeast quarter of the southeast quarter of section 2, the drift was 372 feet thick and the Trenton was struck at an average depth of 984 feet. As no Niagara rock was found no casing was necessary. One well put down in January, 1896, started at 120 barrels, and in June was yielding twenty barrels daily. A pumping station of the Buckeye Pipe Line is located on the southwest quarter of this section.

On the A. Letts farm, in the southeast quarter of section 5, eighteen wells have been drilled, the Trenton being found at an average depth of 970 feet, and the average initial production of the wells being sixty barrels.

The south half of section 6, all of section 7 and the north half of section 8 are practically undrilled on account of the deep drift. On the south half of section 8 several fair wells have been drilled, the drift on the northwest quarter of the southeast quarter being 437 feet thick and the Trenton 968 feet down.

Sections 9 to 12, inclusive, contain some excellent wells, one on the Bechtel farm in section 10 having yielded 101 tanks in 100 days, and in October, 1896, when two years old, was producing thirty barrels daily. However, the most productive well in the township at that date was located on the southwest quarter of the northeast quarter of section 11. It was completed in July, 1896, and had an initial production of 200 barrels. In October it was still yielding 180 barrels of oil and sixty barrels of water daily. In it the Trenton was struck at 981 feet, and the first oil at 1,000 feet.

In the next tier of sections the north halves of 13 and 14 comprise some good territory; while the south halves have only a few very light wells, and lie just within the border of the producing field, no wells being found between West Liberty and Portland.

Section 15 contains but two light wells, while on the south halves of 16 and 17 no drilling has been done. The north halves of these sections contain some fairly productive wells. Section 18, the north half of 19, and all of 20 and 21 have had a number of bores put down which have yielded only gas.

The south half of section 19, the northwest quarter of section 30, and the adjacent territory to the west in sections 24 and 25, Penn Township, have embraced one of the richest areas in the Indiana field, five or six wells thereon having started off at 400 barrels each, and a number of others at 100 to 250 barrels.

On the northwest quarter of section 22 two light wells are located, and in the northwest of section 24, and the northeast of section 25, a showing of oil resulted in the only two bores put down in those sections. No drilling has been done in sections 26, 35 and 36. A few light wells are located in the north half of section 28 and one in the northwest quarter of section 27; the south halves of these sections being as yet undrilled.

Sections 29, 32 and the south half of 30 have as yet developed only gas, though one or two wells in 29 showed a large quantity of oil when first drilled in, but the supply was soon choked off by the gas, and the wells therefore abandoned.

All of section 31 and the northwest quarter of 33 can be classed as good territory; while one very light well in the northwest quarter of 34 has stopped drilling to the eastward.

There is little doubt but that many good wells will yet be located in Jackson Township. Much territory has been unnecessarily condemned on account of a gas well or dry hole having been put down between it and the known limits of producing territory.

All the central parts of the township which now yield gas, will eventually yield oil in greater or less amounts, though there is little chance of that area proving as rich as the two northern tiers of sections or the pool in sections 19 and 30.

PENN TOWNSHIP,

Jay County, comprises but 30 square miles, the western tier of sections of township 24 north, range 12 east, being attached to Harrison Township, Blackford County.

Of this area little more than one-half is at present producing oil, though almost the entire township lies within the productive area of the Indiana field.

The north half of section 1 contains a number of good wells; while the south half is within the limits of the deep drift and has but two bores, southeast quarter, each with but a showing of oil.

The south half of section 2 is undrilled, while the north half is fair territory, but not equal to that on either side. No drilling has been done in the southwest quarter of 3 and the southeast quarter of 4, but the remaining parts of these sections as well as all of 5, 8, and the west half of 9 is good productive territory. In the south half of 5 the Trenton ranges between 1,026 and 1,032 feet below the surface. A pumping station of the Buckeye Pipe Line is located on the northwest quarter of section 8 and another near the center of section 23 of this township.

Owing to the presence of the deep drift in the old preglacial channel, the east half of 9 and sections 10, 11 and 12 are untested; except the southeast quarter of 12, where a light producing well has been sunk, the drift at this point being 410 feet thick. One dry hole has been put down in the southeast quarter of 13, and the section thereby condemned. Sections 14 and 15 produce gas rather than oil, the region about Balbec furnishing much gas for the city of Bluffton. Section 16 and the south half of 17 are undrilled, while the north half of 17 contains a number of good wells. The west half of 20 is also a good territory; the east half, together with sections 21 and 22 belonging to a gas-producing area which is prominent in the center of this township. In this area the Trenton is usually found at a depth of 960 feet, showing that the crest of an anticline runs through the sections noted. Section 23 and the south half of 24 contain good wells; the north half of 24 having been condemned by four dry holes.

On the northeast quarter of section 25 is located the farm of W. S. Gardner, where the first wells of the famous "Gardner pool" were put down, several of which started off at more than 400 barrels each. This "pool," as far as developed, occupies about one and one-half square miles in sections 24 and 25, Penn, and 19 and 30, Jackson Townships. The land lies mostly in a valley, surrounded by higher ground on all sides. These higher knolls and ridges, such as "Tusey's Knob," in section 24, and "The Twin Hills," in the southwest of the northeast of 25, are composed of great masses of glacial sand and gravel rising 70 to 80 feet above the level of the valley. They are the deposits of a mighty stream which was formed by the receding and melting glacier and show that the water must have moved in a southwesterly direction with a strong and rapid current, eroding the sand and gravel already deposited over a broad area to the northeast, and reassorting and depositing it in the hills and ridges of this region.

A large amount of promising undrilled territory lies within the limits of the oil field to the south and southwest of the Gardner pool, as well as on its northern border, condemned because a few dry holes or gas wells have been put down upon it.

The west half of section 25 and the southeast quarter of 26 have as yet produced no oil, the bores put down yielding gas.

The remainder of section 26 and the east half of 27 contain a number of good oil wells. On the Heller farm, just north of Camden (southeast quarter section 27), the No. 2 Well disclosed the following section:

Drift	50 feet.
Niagara limestone	153 feet.
Hudson River limestone	451 feet.
Utica shale	300 feet.
Trenton struck at	954 feet.
First porous stratum ("pay streak") at	977 feet.
Second porous stratum ("pay streak") at	1,014 feet.
Finished at	1,042 feet.

Between the first and second "pay streaks" there was about ten and one-half feet of hard non-porous limestone. In the Phillips well, 1,000 feet south, the Trenton was struck at 961 feet, and the first porous stratum at twenty feet lower; while the second "pay streak" was not found at all. On the Heller farm two wells were put down on a single acre, one of which started at ninety barrels; the other being a dry hole.

Two other wells just outside the boundaries of the acre were also dry holes.

The west half of 27, and section 28, as far as drilled, have yielded gas, instead of oil. Section 29 has two light wells on the east half, but the remaining wells put down have been gas producers.

In the southern tier of sections, 32 has produced gas from the three bores put down; 33 is undrilled, while 34 has one good well just west of Camden in the northeast quarter. This was put down in May, 1896, by the Manhattan Oil Company. It started at 200 barrels daily, and in October was producing twenty-five. Several additional wells were immediately drilled in the same section, but proved either dry holes or light gas wells.

The south half of 35 and the east half of 36 each contain a number of good wells; while the north half of 35 has been mostly condemned by two or three dry holes, and the west half of 30 has proven gas territory. On A. Graves' farm in the southwest quarter of 35, nine wells have been drilled, the average depth of the Trenton rock being 965 feet. Three of these yielded gas, and the remainder oil, several having started with an initial production of 200 barrels.

Much of Penn Township is, as yet, gas territory; and when the supply of this valuable fuel is exhausted, oil in paying quantities will, doubtless, be found in much of the central and southern sections; but the yield will probably be much lighter than in those localities where the Trenton lies lower, and the bore results immediately in a productive well. As in other portions of the field, a number of tracts lying within the confines of good territory, have been condemned by a dry hole or two. These tracts should, and doubtless would, yield oil, should additional bores be put down. Before oil was found in Jay County, thirty or more gas wells were located in the vicinity of Camden. The numerous bores put down for oil have reduced both the pressure and the volume of the gas, and a number of the wells have had to be abandoned.

KNOX TOWNSHIP.

The northern half of this township has had a number of bores drilled on it, but the only portion now producing oil is the northwest quarter of section 1, where a few light wells are located.

One light well, not now pumping, is located on the northwest quarter of section 4, and several others have been put down in section 11.

The most promising of the latter, known as the "Wingate Well," when first completed, showed 100 barrels of oil and 3,000,000 feet of gas. The oil finally subsided and the well is now producing gas alone.

GREENE TOWNSHIP

lies wholly without the present productive area, but a number of bores within its bounds have developed oil in small quantities. One of these was in the northwest quarter of section 3, and another on the banks of the Salamonie River in the west half of section 8.

The first well to show oil in Jay County was drilled in 1887 on the Penn farm, two and one-half miles west of Portland (northeast quarter of northwest quarter of section 24), Greene Township, by Benjamin Fulton, since noted as an oil operator. The well was drilled for gas, but without shooting yielded thirty-five barrels of oil a day for several days. There being no pipe line or storage facilities, the well was capped in and abandoned.

The next year the "Gilbert Well" was put down on the same quarter section. It yielded much gas and flowed, without pumping, enough oil to fill a large tank. It has been recently overhauled and, according to

Mr. Fulton, was yielding ten barrels of oil daily in June, 1896. The Trenton was found in these two wells at a depth of about 970 feet, the following being a record of the section of the Gilbert well:

Drift	42 feet.
Niagara limestone	193 feet.
Hudson River limestone	435 feet.
Utica shale	300 feet.
Trenton struck at	970 feet.
Finished at	995 feet.

In the southwest quarter of section 10, Wayne Township, a bore was put down, the Trenton occurring at 1,035 feet, and a small quantity of oil was found, but not enough to warrant further drilling in that region.

In Richland township, in the southwestern corner of Jay county, a number of the wells put down for gas have in the past shown the presence of oil in small quantities. This fact led E. Priddy, a successful operator from Findlay, Ohio, to put down a test well for oil on the farm of Evan Evans, one mile southwest of Redkey. This well was drilled in October, 1896, and furnished the following record:

Drive pipe	59 feet.
Casing	278 feet.
Trenton struck at	980 feet.
Oil, showing only, at	1,000 feet.
Salt water at	1,030 feet.
Abandoned at	1,070 feet.

* * *

At New Corydon, in the northeastern part of Jay County, two wells were put down in 1895, one of which showed quite a quantity of oil, and the other a dry hole.

* * *

That the Trenton rock underlying the surface of Knox, Greene, Wayne, Bear Creek and Wabash Townships contains oil in greater or less quantities has been shown by the numerous bores in which it has been already found. There are doubtless large areas of those townships where the rock occurs in the porous condition necessary to the accumulation of oil in quantity, but those areas can only be determined by future drilling. The bores put down in those townships up to the present have been so located that they, for the most part, happened to miss the accumulations. Where one good well is found others will most likely be found near it; oftentimes, however, the second well happens to be located in the wrong spot, proves a failure, and so disheartens the operator.

The Ohio and Indiana fields are, without doubt, connected, and the line of connection will, in the future, be found in northern Jay or southern Adams Counties, perhaps in both.

Again, when the present gas area of Jackson, Knox and Greene Townships shall have yielded up its more subtle fluid the oil will rise to take its place, and a light producing oil field will result. Where the Trenton lies ten to thirty feet lower than in the area at present yielding gas, oil will be found in larger quantities; but drilling is the only method by which the location of such areas can be determined.

BLACKFORD COUNTY.

This county comprises but 165 square miles, embraced in four civil townships. It lies west of Jay, south of Wells and east of Grant Counties. The surface is for the most part level or slightly rolling, the only hills being due to the eroding action of water. The soil, like that of the surrounding counties, is fertile, being of glacial origin and containing, therefore, all the constituents needed by the cereals and grasses. The principal products are the standard cereals, wool and live stock.

The Salamonie River flows diagonally across the northeastern township and with its tributaries drains the northern half of the county; while Lick Creek, a tributary of the Mississinewa, drains the southern half.

The Ft. Wayne, Cincinnati & Louisville Railway crosses the county from north to south, and the Pittsburgh, Cincinnati & St. Louis from northwest to southeast, the two crossing at Hartford City, the county seat.

About one-fourth of the area of the county is at present producing oil. This area occupies the northern two-thirds of Harrison Township and the northeastern fourth of Washington Township.

Montpelier, in the northern part of the former township, being the closest railroad town to the rich fields of the southern part of Wells County, has, within recent years, become the principal oil center of the Indiana field. From it most of the drillers and operators of Wells and Blackford Counties draw their supplies, and several Eastern companies which manufacture such supplies have branch houses located in the town.

HARRISON TOWNSHIP.

This township comprises forty-two square miles, the western tier of sections of the Congressional township 24 north, range 12 east, being added to township 24 north, range 11 east, in its make-up. Of this area, twenty-five square miles are at present producing oil in greater or less quantities.

The territory embraced in the sections of the upper tier may be classed as good, with the exception of the northern halves of sections 1 and 2, which yield much gas in connection with the oil, and section 6 (24 north, 11 east), where the wells have proven light producers.

In the southern outskirts of Montpelier, southwest quarter of section 3, is the oldest oil well in the county. It was put down in 1890 and started with a good flow of gas and about twenty-five barrels of oil per day. A record of the formation passed through by the bore of this well is as follows:

Drift	17 feet.
Niagara limestone	233 feet.
Hudson River limestone	432 feet.
Utica shale	280 feet.
Trenton struck at	962 feet.
Total depth	981 feet.

The well in June, 1896, was still yielding oil at the rate of about six barrels a day.

In the western part of section 5 and in section 6, the Trenton is found rather high, 960 to 970 feet, and much gas is given off with the oil.

The largest pumping station of the Buckeye Pipe Line Company is located on the bank of the Salamonie River, northwest quarter of section 3, a short distance northeast of Montpelier. The oil from the receiving tanks of the producers in the Indiana field is pumped by the smaller pumping stations of this company to this large one at Montpelier. Two 25,000 barrel tanks are here located, and all Indiana oil, except the small amount pumped by the station at Ruth, Wells County, passes through these tanks and is pumped through two mains to Preble, Ohio. In September, 1896, an average of 14,000 barrels a day was being pumped from the Montpelier station.

Of the second tier of sections, the wells put down in No. 7 have proved light producers, while those in No. 8 have been uniformly good. In No. 9 the northern half is light territory. The southern half is somewhat better, being, seemingly, a northern extension of the good productive area of section 16. The northwest quarter of No. 10 is a good producing area, but the south half of that section has developed nothing but dry holes. The northeast quarter and sections 11 and 12 are considered very light territory, the wells starting out at twenty to forty barrels and soon dropping down to a low output. In section 7 (24 north, 12 east) the yield rises again and a number of good wells are located thereon.

Starting back on the next tier, No. 13 (24 north, 12 east) and Nos. 13, 14 and the east half of 15 contain only light producing wells. The west half of 15, all of 16 and 17, except the northwest quarter, where gas territory sets in, are highly productive. This area, together with the north half of 21, seems to form a pool, surrounded by much poorer territory. On the Evers farm, in the northwest quarter of 15, the average depth of the Trenton in eight wells was 1,000 feet, and the average initial production 125 barrels. In section 18 some light producing wells are found in the northern half, while the southern half has so far yielded gas. Many of the gas wells in this township and Washington were put down before oil was discovered. As a consequence, they were stopped in the upper porous stratum, or "pay streak." If drilled deeper they would have struck the second porous stratum and have yielded both gas and oil. In section 19 and the north half of 30, a number of good wells were located in the season of 1896, the known limits of the productive field being extended for about two miles to the southwest. On the McMahan farm, northwest quarter of section 30, the Trenton was found at 976 feet. Section 20 is undrilled, except the northeast quarter of the southwest quarter, where a bore producing gas was put down. The north half of 21 contains a number of good wells, while the south half, as well as section 22, is untested. Section 23 contains two dry holes in its northwest quarter, and 24 several gas wells on its west half, the remainder of the two sections being undrilled.

The preglacial channel through the Niagara, mentioned on page 65, extends in a southwesterly direction through several sections in this part of the township, and has prevented drilling on account of the much greater expense necessary in getting through the deep drift. Its limits have not as yet been defined, but several bores in section 13 (range 11) and section 19 (range 12) required over 400 feet of drive pipe. A gas well in the southwest quarter of section 29 passed through 405 feet of drift, so that the channel probably passes out of the township through sections 30 and 31.

Section 19 (24 north, 12 east) has proven light up to the present, while on the north half of 30 (in the Godfrey Reserve) a number of good wells were put down in 1896 by Dr. White, of Indianapolis.

An average record, as furnished by these, was as follows:

Drive pipe	128 feet.
Casing set at	254 feet.
Trenton struck at	968 feet.
Finished at	1,035 feet.

Farther south the Trenton rises, being found at 934 feet in section 31 (24 north, 12 east). As a result, nothing but gas has been found in the bores put down to the westward in the southern third of Harrison Township, though a showing of oil was found in the one in the southwest quarter of section 29, and in another located on the south margin of the deep drive region in the northeast quarter of section 34.

WASHINGTON TOWNSHIP (24 NORTH, 10 EAST).

The line marking the southern limit of the present known productive oil area of the State enters this township on the east in section 24, and passes diagonally to the northwestern corner. About eleven square miles of the township are, therefore, included within the Indiana field.

Of the northern tier of sections Nos. 1 to 5, inclusive, are all good producers, while 6 is yet untested. The Buckeye Pipe Line has a pumping station on the northwest quarter of section 3. Sections 7, 8 and 9 are practically untested, the northeast quarter of 8 having two light wells, and the corresponding quarter of 9, one dry hole. In section 10 the production has been a good one, but in 11 salt water rather than oil has been the result of drilling, especially in the south half. Section 12 is good territory, while the bores put down in 13 and the northern halves of 14, 15, 16 and 24 have all been light producing. The remaining sections of the township have yielded only gas where drilling has been done; though in some instances, as in the wells put down by the Fort Wayne Gas Company in sections 21, 22 and 23, a good showing of oil has also resulted.

As the yield of gas diminishes much, if not all, of the territory in the southern half of both Washington and Harrison Townships will in the future produce oil. As noted above, where the two are found in conjunction the gas occupies the upper "pay streak" and the oil the lower. The yield of oil will not, therefore, be so great as in the areas already partly drilled in the northern halves of these townships.

GRANT COUNTY,

in which the most westward extension of the Indiana oil field is located, lies west of the counties of Wells and Blackford, and south of Huntington and Wabash Counties. It comprises an area of 418 square miles, the surface of which is, for the most part, level or slightly undulating, though in the vicinity of the Mississinewa River many hills, due to erosion, and from 50 to 100 feet above the level of the river bed, are found.

The Mississinewa enters the county near its southeastern corner, and, flowing in a northwesterly direction, leaves it on the northern border, six miles east of the northwestern corner. In the early history of the county it was navigable for flatboats, which were loaded at Marion and transported, via the Wabash and Ohio Rivers, to New Orleans. It and its tributaries drain the greater part of the county; but the western tier of townships is drained by Pipe and Grassy Creeks, and the northeastern corner by Black Creek, a tributary of the Salamonie River.

The soils of the county are mostly of drift origin, and, for the most part, are fertile, though in some localities a lack of necessary drainage has rendered their tillage unprofitable.

The transportation facilities of the county are excellent, the T., St. L. & K. C., the C., W. & M., and the P., C. & St. L. railways passing entirely through it and having a common junction point at Marion, the county seat.

The oil bearing territory of Grant county is at present limited to the northeastern corner, and comprises the greater portion of Van Buren township and a small part of Washington township. This area will now be treated in detail.

VAN BUREN TOWNSHIP (25 NORTH, 9 EAST.)

The northern half of this township has proven one of the best portions of the Indiana oil field. It owes its development largely to the acumen and energy of Mr. E. J. Little, a progressive and well informed operator, who, after selling his interest in Nottingham Township, and about Geneva, Adams County, entered the Van Buren field after it had been practically condemned, and, undaunted by several failures, stuck to it until he proved it what he believed it to be, a rich oil territory.

The first well which produced oil in Grant County was put down for gas in 1890 by J. H. McBride, of Butler, Ohio. It was located in the outskirts of the town of Van Buren, in the northwest quarter of section 15, and its record as obtained and preserved by Mr. Little is as follows:

Drive pipe	155 feet.
Casing	380 feet.
Trenton struck at	996 feet.
Total depth	1,033 feet.

It yielded a small amount of gas and some oil, but the latter was not thought to be in paying quantities, and as there was no pipe line to carry it away, the well was not pumped and was soon abandoned.

In August, 1893, E. J. Little drilled the second well in the Van Buren field, on the northwest quarter of section 24. Here the Trenton was found at 1,000 feet, and a natural flow of oil, estimated at fifty barrels a day, resulted. It soon changed into a water well and was abandoned.

The third well was put down by Mr. Little on the southeast quarter of section 9, just north of Van Buren. It yielded but ten barrels a day and was soon abandoned.

In the spring of 1894 a fourth well was put down on the J. B. Cory farm (southwest quarter of section 16). It flowed oil for some time, but not enough to warrant the putting in of a pipe line.

In the fall of 1894 Bettman, Watson & Co. entered the field and put down two wells on the southeast quarter of section 15. The yield from these wells was sufficient to justify the Standard Oil Company in laying a pipe line to Van Buren, and the field began to open up immediately after the line was completed.

The first four sections of Van Buren Township have not, up to the present, proved very promising territory. The north halves of 1, 2 and 3 are untested, while the wells on the south halves have proven light.

Section 4 has several large salt water wells on its east half; its southwest quarter contains, however, some fair wells. Sections 5, 6, 7, and the north half of 8, contain good wells; the south half of 8 being untested.

Section 9 is what oil men call "spotted." In the northwest quarter is located one of the best wells in the county. It was completed in March, 1896, and by August 1 had produced twenty tanks of oil. On the northeast quarter a large salt water well is located; while the southwest quarter contains a big gas well, which pumps some oil, and the southeast quarter contains a dry hole. On the north half of section 10 are two dry holes, while the south half contains a number of light producing wells. The average of four well records in this section is as follows:

Drive pipe	106 feet.
Casing set at	409 feet.
Trenton struck at	982 feet.
Total depth	1,020 feet.

Until 1896 it was thought that sections 11 and 12 would prove like those of the north, rather light in production. However, Mr. Jas. H. McCormick, an experienced operator from Bluffton, decided to test them, and, as a result, has eleven good wells, ten of which, in the month of October, yielded 5,000 barrels of oil. In section 11 the drift is about 114 feet thick and the Trenton is found at an average depth of 970 feet. The Buckeye Pipe Line has its most western pumping station in the southeast quarter of this section.

In the next tier of sections, numbers 13, 14 and 15 have proven excellent territory. On the Creviston farm, in the northwest of 14, the Trenton lies at 968 feet, and ten wells started out with an average initial production of 60 barrels. On the John Swisher farm, in the northeast of 15, the record of a well finished on April 7, 1896, was as follows:

Drive pipe	108 feet.
Casing set at	410 feet.
Trenton struck at	968 feet.
Total depth	1,018 feet.

Initial production, 160 barrels.
Production June 12, 25 barrels.

On the Boxel farm (southwest quarter of 15) the Trenton was found at 965 feet, 118 feet of drive pipe and 385 feet of casing being necessary. In June, 1896, the first well on the Doyle farm, in the same quarter section, was finished with an initial yield of 100 barrels. The second, 600 feet south, finished in August, started at twenty-five barrels. By the first of October they were yielding thirty and ten barrels, respectively. In general, it may be said, that in the immediate vicinity of Van Buren the drift is 105 feet thick and the Niagara limestone about 305, making 410 feet the amount of casing used.

Section 16 has yielded much salt water and but little oil, except on the southeast quarter, where a number of good wells are located, the Trenton being found here at 968 feet, while in the salt water wells in the other portion of the section it ranged between 983 and 990 feet.

To the west the yield is much less, the east half of section 17 being very light territory. The west half is better, and, with the south half of 18 and the north halves of 19 and 20, may be termed fair. A number of wells were put down in these sections in 1896 by the Bettman, Watson, Bernheimer Company, of Marion. On November 1 the average yield of eighteen of these wells in the immediate vicinity of Landessville was said to be ten barrels a day. The north half of 18 and the south halves of 19, 20 and 21 are untested, while the north half of 21 has three light wells and two dry holes to its credit.

Both 22 and 23 are good productive sections. On the Kirkpatrick farm, in the northeast quarter of 22, is located the well which had the greatest initial production in the Indiana field. It was finished in June, 1896, and after being shot flowed at the rate of 150 barrels an hour for two or three days. The flow then stopped, and after a few days' pumping the well began yielding nothing but salt water. This was kept up for several weeks, when the oil came in once more, and in October it was producing fifteen barrels daily. But few spouting oil wells have been drilled in Indiana, and where found their spouting continues for but a few days. The average depth of the Trenton in section 22 is 967 feet.

The west half of section 24 contains some fair wells, the east half being untested. A few light wells have been finished in the northwest quarter of 25 and the north halves of 26 and 27, the remainder of these sections, as well as all others in the two southern tiers of the township, being untested up to December 1, 1896.

WASHINGTON TOWNSHIP (25 NORTH, 8 EAST).

In this township oil has been found in paying quantities only in sections 1, 12, 13, 24, 25 and 26. On the White farm, northwest quarter of section 12, a well was finished in May, 1896, which started at ten barrels an hour, but the yield soon dwindled, and in November it was producing much salt water and little oil. Several bores which produced gas have been drilled in the southwest quarter of 1 and south half of section 2, as well as in the north half of 11.

The south half of section 12 and the north half of 13 are untested. The south half of 13 and section 24 contain a number of fair wells. One or two light producing bores are located in the north half of 25, while on the J. C. Tinkle farm, in the south half of 26, is a well which was finished October 15, 1896, and started at seventy-five barrels a day. This well is farther southwest than any in the Indiana field, and is probably the forerunner of a number which will be put down in this extension during the winter of 1896–7. In sections 25 and 26 the Trenton rock dips to the south, and an average record, as shown by the bores, is as follows:

Drift	132 feet.
Niagara limestone	368 feet.
Hudson River limestone	250 feet.
Utica shale	235 feet.
Trenton at	985 feet.
First "pay streak"	1,009 feet.
Salt water	1,023 feet.

Outside of the productive area as shown on the map, few wells have been put down in Grant County which showed the presence of oil. One in the northeast quarter of section 36, Washington Township, has yielded a small amount. Another on the land of Joshua Strange, near Arcana, Monroe Township (24 north, 9 east), started in as a heavy gas producer, and finally began to show oil in the fall of 1896. Two tanks were filled, but, there being no pipe connection, the well was capped in and pumping stopped.

* * *

The Van Buren oil field is noted for the small number of "dry holes" found therein, the relative proportion being less than in any other part of the Indiana field, unless it be in the southern half of Hartford Township, Adams County. The oil-bearing stratum of the Trenton is softer and more easily drilled than in Wells County. As a result, the initial product is greater and drops down faster. For example, a 100 barrel well in Wells County will be yielding fifty barrels at the end of two or three months. The same well, if in the Van Buren field, would probably start at 150 to 200 barrels, and be down to twenty or thirty in three months. There seems to be about so much oil to a certain area of territory, and the more rapidly it is taken out the sooner the end comes. As yet, however, few of the wells in the Van Buren territory have been abandoned for lack of production. The output reaches a certain limit—as five to eight barrels a day—and holds it steadily for months, or even years.

As in the eastern part of the field, there are usually two "pay streaks" found in Grant County, the one seventeen to twenty feet below the top of the Trenton, the other twenty-eight to thirty-eight feet below. In many gas wells put down in the early history of the field the upper streak alone has been pierced; if when the well has ceased to yield gas it be bored deeper the oil in the lower stratum will be reached. Much less paraffine is found in the oil of the western part of the Indiana field than in that of the eastern, and especially the Trenton limestone field of

Ohio. In the latter the hole has to be cleaned up once a month; in the Van Buren field once a year often suffices.

The limits of the known oil bearing area of Grant County will, in all probability, be extended westward over the greater portion of Washington Township; and as the yield of gas continually diminishes, a lighter producing territory will probably be found in the northern halves of Centre and Monroe Townships. South of this developments have not been sufficient, as yet, to foretell what the future will bring forth.

HUNTINGTON COUNTY

comprises an area of 384 square miles, lying west of the counties of Allen and Wells and north of Wells and Grant. The general surface is similar to that of the counties already noted—a level plain, unmarked by any prominent hills or elevated points, the average elevation being about 740 feet above the level of the sea. The southern third of the county is drained by the Salamonie River, the central and northern thirds by the Wabash River and its tributaries.

The soil of the county is mostly of glacial origin, varying much in constituents and quality. In most places it is underlaid by a stiff, tenacious clay which retains the surface water and necessitates artificial drainage. Where properly drained it yields large crops of the cereals and grasses. The alluvial soils of the extensive areas of bottom lands along the Wabash and Salamonie Rivers are above the average in fertility, and their crops aid largely in giving Huntington the rank which it holds among the better agricultural counties of northern Indiana.

As in the other counties composing the oil area of Indiana, the only outcrops of rock are those of the Niagara formation. In the vicinity of Huntington, the county seat, large quantities of lime are burned from this rock, and the quality of the product has given it a reputation second to none in the State.

Two railways, the Chicago & Erie and the Wabash, cross the county, the former from northwest to southeast and the latter from northeast to southwest, while the "Clover Leaf" cuts across the southeastern corner.

The area of Huntington County, at present producing oil, is small, being limited to the southern third of Jefferson Township and the southeastern corner of Salamonie Township, though one or two bores in Wayne Township have given a fair yield, but not enough, as yet, to warrant the laying of a pipe line to them.

JEFFERSON TOWNSHIP (26 NORTH, 9 EAST).

The most northern well in this township is a test well located on the Weaver farm, southwest quarter of northwest quarter of section 21. It started October 1, 1896, at about 100 barrels a day. The nearest producing territory to it is in the south half of section 28, where several good wells were drilled in June of the same year. On the W. F. Trammel farm the following record was furnished by a bore finished June 10:

Drive pipe	165 feet.
Casing	415 feet.
Trenton struck at	1,001 feet.

Initial production, 100 barrels.
Production October 1, 15 barrels.

The territory between the Weaver well and the south half of 28 is as yet untested; but, lying between two productive points, it is counted as good until it is proven otherwise.

The southeast quarter of section 29 contains two light wells, and the southwest quarter of 27 several good ones; while in the northwest quarter of 26 a dry hole is located, and in the southwest quarter of the same section, where the Trenton was found at 977 feet, a fair well came in, in December, 1896. This comprises the results of the boring done in this tier of sections to date.

In the south tier, the northeast quarter of 31 has several good wells located on it. The remainder of the section and the north half of 32 are untested; while the yield of the south half of 32 is light. Section 33 and the northwest quarter of 34 contain as good wells as are found in the township; the portion of 34 being especially rich. The south half of that section has, up to the present, yielded only light wells. The production in sections 35 and 36 has also been generally light, though some good wells have been recently put down on the John Karringer farm, east half of northwest quarter, section 35, where the Trenton was found at 980 feet.

Outside the present field, I was able to hear of but one bore that had been put down for oil in Jefferson Township. It was located on the Satterthwaite farm (east half of the southeast quarter, section 7). The Trenton was found rather high, 964 feet, but the bore yielded salt water only.

SALAMONIE TOWNSHIP.

The oil operations in this township have, up to the present, been confined to sections 25, 26, 34, 35 and 36, in the southeastern corner. Outside these sections but two bores have been put down; one at Warren, in section 29, which resulted in a dry hole, and the other in the southwest quarter of section 22, where the Trenton was found low, 1,005 feet, and a salt water well, with but a showing of oil, resulted.

The wells in section 25 are located in the southeast quarter, the southwest quarter, and one in the northwest quarter. All are fair producers. Five or six wells are producing near the center of 26 and three in its southeast quarter, the remainder being undrilled.

Only the south half of section 34 has been tested and salt water resulted in the two bores put down. Two salt water wells and one fair producer have been drilled on the west half of 35, while the east half has a number of good wells, the best one, close to the south line of the section, making sixty barrels a day when it was two and a half years old. The Trenton in the east half of 35 and the west half of 36 is found at 985 to 990 feet. The southwest quarter of 36 is pretty well drilled over, sixteen bores having been put down upon it, twelve of which resulted in fair wells. The southeast quarter of this section has been condemned by two bores which developed salt water only, while the north half has a few fair wells within its bounds.

The trend of the drilling in this township seems to be to the northwest. There is no reason, however, why oil should not be found in the territory south of Warren, the one dry hole in that section having been put down at an early date and only to a shallow depth in the Trenton.

WAYNE TOWNSHIP.

The Sterling Oil Company has put down several test wells in this township. A bore on the John Sparks farm (northeast quarter of southwest quarter section 15) developed salt water. Much difficulty was experienced in sinking this well, five different holes having been started. The drift was found to be 153 feet thick and 515 feet of casing was necessary.

On the A. T. Searles farm (southwest quarter section 24) a bore finished in July, 1896, showed the following record:

Drive pipe	301 feet.
Casing set at	515 feet.
Trenton struck at	986 feet.
Total depth	1,024 feet.

Initial product, 100 barrels.
Output October 1, 10 barrels.

Two tanks were filled, and no pipe line being in the vicinity, the well stopped pumping. This is the most northwestern well in the Indiana field.

On the George Babcock farm in section 35, a well drilled in September, 1896, yielded gas only.

The three townships of Wayne, Jefferson and Salamonie lie on the northern limit of the Indiana gas field. The oil area may, in time, be found to cover the greater portion of the territory embraced within their bounds, but the chances of its extending farther north in the other townships of Huntington County are very remote. At the present writing, the best prospective territory in the county lies in the southwestern fourths of Salamonie and Jefferson Townships.

CHAPTER III.

THE PRODUCTION OF PETROLEUM IN INDIANA.

The raising of petroleum from the porous stratum or reservoir in the depths of the Trenton, where it has laid for thousands of years, to storage tanks upon the surface of the earth, where it can be utilized by man, is termed the "Production of Petroleum."

The evolution of the processes involved in the present advanced methods of production from the primitive ones used by the first "oil operators" in the United States, has been a wonderful one and would prove a story of surpassing interest to the practical operator of to-day.

The different steps necessary to the successful development of a good oil property are many, and the tyro who enters the field against operators who have spent a life-time in mastering the details of producing oil at a minimum cost, often finds himself handicapped before he has completed his first well.

Choosing a Locality for Operating.

The first step necessary in the production of oil is the choosing of the locality in which the operations will be carried on. In this step it will be found that the old operator, who has watched the growth of a field from the beginning, is usually wise enough to locate his future wells within the limits of the known productive territory, provided he can procure the necessary leases. The beginner more often betakes himself to "promising" territory just outside the limits and puts down a "wild-cat" bore. Any one who makes a special study of the Indiana field will soon note that the Standard Oil Company and other large operators do little "wild-catting," but profit by the experience of the small operators who indulge in it. "Wild-catting" must, however, be done by somebody, as there is no known method of fixing the limits of a field except by test bores put down by speculative individuals.

Usual Terms of a Lease.

After deciding on a piece of territory it must either be bought outright or leased from the owner for a term of years. In most cases it is leased, usually for a period of five years, or as much longer as production continues. If the adjoining territory is untested the farmer usually receives from one-eighth to one-sixth royalty on the future production, with a stipulation that drilling is to begin within one or two years, or that a stated rental per acre shall be paid until the first well is drilled. The landowner retains all rights over the surface of the land with the exception of the portion necessarily occupied by the derricks, power houses and storage tanks. Of a farm of eighty acres not more than three need be kept from cultivation, even though it contain, in time, its full quota of wells. If a good well has been put down on adjoining territory, the farmer often receives a bonus of from $300 to $1,000, or even more, in addition to the royalty and rental. In many instances the supposed rich strike in time proves of little value. The lease expires, without being drilled, and the farmer is ahead a sum equal to the bonus advanced.

If, on the area leased, some good wells are developed, the lease, like the franchise of a street railway, becomes the most valuable part of the so-called "oil property;" and with the wells already in operation is sometimes sold for large amounts. Even though no wells are drilled on a leased farm, the lease often changes ownership a number of times before it expires. The following is a form of lease in common use in the Indiana field:

In Consideration of the sum of.....dollars, the receipt of which is hereby acknowledged, ..., of ....County, in the State of Indiana, first party, hereby grant unto..............................., second party, their heirs and assigns, all the oil and gas in and under the following described real estate, together with the right to enter thereon at all times for the purpose of drilling for oil and gas, and to erect and maintain all buildings and structures and lay all pipes necessary for the production and transportation of oil or gas taken from said premises. Excepting and reserving, however, to first party the..............part of all oil produced and saved from said premises, to be delivered in tanks at wells, or in the pipe lines with which second party may connect their well, or wells; said real estate being described as follows:

All that certain tract of real estate situated in the Township of............, County of ...., in the State of ...., bounded and described as follows, to wit:

....

....

containing..................acres, more or less.

To have and to hold the said interest in and to the above premises on the following conditions:

If gas only is found, second party agrees to pay............dollars each year for the product of each well while the same is being marketed off the premises, and first party may use gas free of cost to heat........stoves in dwelling house during said time.

Whenever first party shall request it, second party shall bury all oil and gas lines being laid through tillable land, below plow depth, and pay all damages done to growing crops by reason of burying and removing said pipe lines.

No well shall be drilled nearer than........feet to the house or barn on said premises.

In case no well is completed within..........from this date, then this grant shall become null and void between all parties hereto, unless second party shall pay to said first party............dollars, annually, for each year thereafter the completion of such well is delayed.

The second party shall have the right to use sufficient gas, oil and water to run all necessary machinery for operating for any purpose on said real estate, and shall also have the right to remove all its property from said premises at any time.

....

....

It is understood between the parties to this grant that all conditions between the parties hereto shall extend to their heirs, executors and assigns.

IN WITNESS WHEREOF, the parties to this grant have hereunto set their hands and seals this..........
day of ...., 189..

........................[SEAL]

........................[SEAL]

WITNESSES.

....

....

..............................*Acres*.

AGREEMENT.

FROM

....

....

TO

....

Date......................, 189..

LOCATION.

Sec. No........ ....*Township*

......................*County*

State of..................

Rec'd for Record......................*189..*

Time Recorded......................*189..*

In Book........*Page*........

Recorder..........................*County.*

State of.............. }
County of .... } ss.

On this....day of............189.., before me, a............, in and for said county, personally appeared........................, to me well known, and acknowledged the signing and execution of the within instrument and grant to be....free and voluntary act for the uses and purposes therein set forth.

Witness my hand and............seal.

....

....

After securing a lease, the operator must choose the site for his first well. It is usually the custom to drill at some point about 300 feet from the property line in order to first obtain the oil which might otherwise be raised by the operators of adjoining leases. Various circumstances, such as the dip of the oil bearing rock, variations in the surface level of the tract leased, the location of a permanent power house, etc., are often considered in determining the site of the well. If other wells are down on adjoining leases the production of the first well, as compared with that of the older ones, can be used to gauge the location of future bores. If a well holds up to ten or fifteen barrels a day for a year or two, the chances are that it is close to or connected with a large area of porous rock, and that better wells may be located somewhere in the immediate vicinity. The wells are usually put down about 600 feet apart; that distance, in the language of the oil field, being termed "a location."

Locating the Wells.

An unwritten law exists among operators that the lessee of a tract of land shall immediately put down wells when producing wells are drilled on adjoining territories. This is done to protect property lines and prevent the oil underlying one tract from being drained off through another.

As to the amount of acreage to be assigned to an oil well, opinion varies greatly. On the larger leases not less than ten and often twenty acres are given to the well. On the smaller leases one to every eight acres is often drilled. The degree of the porosity of the rock should govern the acreage to a large extent. Where comparatively open, each well drains a larger territory, and fewer bores are necessary than where the pores are close.

Having selected a site for his well, the operator next contracts for a rig, the main feature of which is the derrick. This consists of four strong uprights held in position by ties and braces and resting on strong wooden sills, which are preferred as a foundation to masonry. The derrick is used as a support for a sheave called the crown pulley, which must rest at a sufficient height to swing the heavy drilling tools free from the ground. The average height of the derrick is seventy-two feet, and it forms the most conspicuous object which characterizes an oil field.

The Rig.

With the derrick are included under the term "rig" all the woodwork and its necessary iron fittings so put together that when boiler and engine are in place drilling can at once begin. The bull wheel and shaft on which the cable supporting the drilling tools is wound; the walking beam to give vertical motion to the tools, and the band wheels for transmitting power from the engines to the movable parts are, next to the derrick, the more important parts of the rig.

The construction of the rig is usually undertaken by a contractor known as a "rig builder," for a certain specified sum. In Indiana in 1896 the price paid for the rig complete was about $275.

After the well is completed the rig is, in most cases, left standing, though small operators often take it down and use it for another well. A considerable saving of outlay for lumber and rig irons is thus effected, but if the well stops flowing or needs cleaning out a new rig, usually smaller and less expensive, must be built.

The rig having been completed, the contract for drilling the well is let. The larger operators own their own "strings of tools" and employ rig builders, drillers, etc., by the month instead of contracting for each well. The head driller or contractor owns his own string of tools and portable engine. His tools cost anywhere from $700 to $1,500, according to number and quality. His engine is of a pattern built especially for the purpose and costs about $450. Sometimes the contractor owns several, perhaps a dozen, strings of tools, and is drilling a number of wells at the same time.

Drilling the Well.

In the Indiana field in 1896 the contract price for drilling was fifty cents a foot. The drilling crew consists of four men, two drillers and two tool dressers, who work in pairs, twelve hours each. It is the duty of the driller to stay close to the mouth of the bore and attend to the drilling proper, turning the cable and the temper screw when necessary and controlling the machinery by cords and lever when changing the tools or sand pumping. The tool dresser is the helper to each driller. He fires the boiler, attends to the engine and machinery and dresses or sharpens the bits as each in turn becomes worn.

The wages paid the drillers in 1896 were $4.00, and the tool dressers $3.00 each per day. The contractor is responsible for accidents and failure to complete a well. The time necessary to put down a bore 50 feet into the Trenton varies much, but is usually from nine to twelve days. The shortest time which came to my notice was six days and six hours, made by J. G. Herriet, a contractor in Wells County.

As already noted, the surface of the territory in the Indiana field is covered with the so-called "drift," a heterogeneous mass of sand, gravel, bowlder-clay, etc., 30 to 250 feet, or, in the Loblolly district, as high as 450 feet thick. Through this a strong iron drive-pipe, furnished by the owner of the well, must be driven, as in pile driving, to the solid bed rock. This pipe is usually eight inches in diameter, sometimes ten, and is fitted with a steel shoe on the lower end. That it may be driven more easily it is usual to drill inside, clean out the earth and cut ahead, loosening the hard clays or breaking any bowlders that may be in the way.

After reaching the Niagara limestone an eight inch bit is used and iron casing, in lengths of 17 to 20 feet and 5⅝ inches in diameter, is set as fast as the drilling progresses, thus shutting off the water. From the bottom of the Niagara to the oil-bearing stratum there is little or no water and a 5½ inch bore is made, the drilling being done through the drive-pipe and casing already down.

Shooting the Well.

As soon as the porous stratum is passed through, if there is a fair showing of oil, the well is torpedoed or "shot" in order to open up fissures in the porous rock and form a cavity therein into which the oil may flow. In the Indiana field it is now the custom to drill into the Trenton 50 to 60 feet, and then, if possible, gauge the shooting so that the rock will be shattered from the bottom of the drill hole to the top of, but not above, the porous stratum. This prevents the explosion affecting the Utica shale overlying the Trenton and so filling up the cavity with loose debris and rendering the well worthless. Nitroglycerine is the explosive used, and the amount depends largely upon the texture of the porous rock or so-called "sand." If it is hard and close-pored, more explosive is necessary than where coarse and friable. In the latter case a large shot shatters too great a quantity and causes too much trouble in cleaning out after the shooting. An average shot in the Indiana field is now 120 quarts, though some operators persist in drilling deep and using 200 quarts in all wells.

The shooting is done by a contractor who follows it as a vocation. He is usually an agent of the company who manufactures the explosive, and often works on the percentage system, receiving from the company a stipulated sum per quart for the explosive sold.

The nitroglycerine is hauled overland from the factory in square tin cans holding eight to ten quarts each, and stored in quantity in buildings erected in some out-of-the-way place at various points in the oil field. When a well is ready to be shot, the agent who does the shooting transports, in a light buckboard buggy, padded and fitted for the purpose, a number of these cans to the well. There the glycerine is poured into cylindrical tin cans, called "shells," about five inches in diameter, and long enough to hold twenty quarts of the explosive. Each shell is conical at the lower end and slightly concave at the upper. As soon as the first shell is filled it is lowered into the bore. When it reaches the bottom the lowering line, by a special device, becomes detached and is drawn up. The second shell is then filled, and when lowered its conical end fits into the cavity at the top of the first. In this manner each of the shells, after being lowered, rests in close connection with the one preceding. The last, or top shell, is fitted in a special manner with a waterproof percussion cap so arranged beneath a flat iron plate that when the latter is struck the cap is exploded and in turn sets off the nitroglycerine. After the lowering line of the last shell has been reeled up, an iron casting, called the "go-devil," is dropped into the bore, and the "shooter" and spectators retreat some distance from the derrick.

A person one hundred yards away will, after an interval of thirty to fifty seconds, experience a slight jarring of the earth, accompanied by a muffled report somewhat louder than a pistol shot. A minute or two thereafter a roaring sound is heard and a solid column of oil and water is seen issuing from the mouth of the bore. This rises higher and higher until it finally reaches far above the derrick and there breaks into spray.* Blown up with it are many fragments of stone, and the remains of the tin canisters and "go-devil" shattered into a thousand particles. Pieces of porous rock blown up from a depth of a thousand feet often weigh six to eight pounds.

The flow of oil resulting from the explosion usually soon subsides, and as soon as possible tubing two to two and a half inches in diameter and reaching to the bottom of the bore, is put in and connected with a tank which has been erected near by. These tanks are cylindrical, are constructed of wooden staves, and are usually gauged to hold 250 barrels each. In such a tank each inch in depth equals two and a half barrels of oil; therefore, in oil field vernacular, a yield of "ten inches a day" means twenty-five barrels. The cost in 1896 of such a tank was eighty dollars.

After tubing the well and connecting it with the tank, the necessary pumping apparatus must be bought, as few Indiana wells flow naturally for any length of time.

If a number of wells are to be drilled a power house is located near the center of the lease and a small engine placed therein. Each well is supplied with an oscillating walking beam, to which the necessary pumping or sucker rods which ply up and down inside the tubing are attached.

Pumping the Oil.

When several wells are pumped by one engine the power is transmittted to the walking beam of each by means of long rods or wire ropes provided with suitable angle-knees to change the direction of the pull. The engine runs an oscillating pull-wheel which gives horizontal movement to the rods radiating from it to the different wells. These rods are suspended above the ground by ropes attached to poles or posts which are set in a row between the power house and well. The pull-wheel draws the rods in one direction, and on the return the weight of the sucker rod, hanging from the walking beam, draws them back. In this way wells have been pumped one mile from the power house, and often as many as twenty wells, and sometimes as many as forty, are pumped by a single engine. More than twenty-five or thirty are, however, too many, for if the power should happen to break down all the wells are stopped. Again, a pumper (the man in charge of the engine and wells) can not look after more than that number and do it right. The fuel used for pumping is usually gas, the wells on the lease often furnishing enough; though in most instances it is piped in from a distance. Oil is used to some extent, and will probably be more used in the future.

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*See frontispiece.

Several of the leading operators about Van Buren and Montpelier have begun to use gas engines for pumping, and so far have been very favorably impressed with their work At Van Buren Mr. E. J. Little, in October, 1896, was pumping six wells at an expense of but $8.00 a month for gas. The engine is so constructed that natural gas and compressed air are blended and then exploded by electricity generated in a small battery at hand. The sudden expansion of the mixture moves a piston and so creates motion. The engines need no attention other than oiling once or twice a day. The pumper has more time to look after the wells and can attend to a greater number of them. The cost of the gas engine has up to the present kept it from more common use, the price of one suitable for pumping being $650 in 1896.

The average cost of the first well on a lease, if drilled to a depth of 1,000 feet, was about as follows in the Indiana field in 1896:

Cost of a Producing Well.

Rig	$275
Drilling	500
Drive Pipe	100
Casing	250
Shooting	110
Tubing and pumping outfit	200
Engine and boiler	500
Two tanks @ $80	160
Belting, etc	85
Total	$2,180

The second well will cost $500 less, as the one engine and boiler will do for both. The larger operators, where putting up their own rigs and drilling their own wells, expend less money. Thus seven wells on one lease close to Van Buren cost $1,100 each, connected to the power. Of seven on another lease in Chester Township, Wells County, where the rig and drilling were let by contract, the first cost $2,400 and the remaining six $1,200 each.

After a tank has been filled with oil the latter must be steamed to reduce the impurities and sediment to a minimum This is done by connecting pipes from the engine with the bottom of the tank, and forcing steam through the oil. The process of "production" is then complete, and the oil is ready for the market.

Cost of Operating a Lease.

The cost of operating an oil lease after the production has been established need not be more than $75 per month; the salary of the pumper being $45 to $50, and the cost of fuel, if gas, about $25. A dozen, or even twenty wells can, however, be operated almost as cheaply as one after they have been connected with the power. An extra pumper may have to be employed, but otherwise no additional expense is entailed.

Where the plant has been established, it will pay to pump as low as two or three wells, even if the yield is only five barrels each per day, provided, the price of oil is fifty cents or more per barrel.

The estimate of expense and income from two five-barrel wells, after deducting the royalty of one-sixth, is as follows:

Expense per month:	
Salary of pumper	$50
Cost of fuel	25
	$75
Income per month:	
250 barrels oil @ 50 cents	$125
Net income per month	$50

With six five-barrel wells on the lease, the income would be $375 and the expense $75; a net gain of $300 per month.

Where a well is inside of producing territory, and promises a fair output, little difficulty is experienced in getting a branch of the Buckeye Pipe Line Company laid to it. This pipe line company is an adjunct of the great Standard monopoly, and up to the advent of the Cudahy Pipe Line, transported all the oil produced in the Indiana field with the exception of a small production in Adams County, which the Manhattan Oil Company controls.

Marketing the Oil.

When a tank is full, or nearly so, the pumper notifies a gauger of the Buckeye Company, who comes and measures its contents and turns it into their line. He at once notifies the Ohio Oil Company (the Indiana branch of the Standard Oil Company), at Montpelier, and, after deducting 2 per cent. for sediment, leakage, etc., certificates are mailed to both the producer and the party owning the land, stating the number of barrels to their credit in the lines of the Buckeye Company, together with the market price of the same. These certificates can be cashed at the various banks in the oil field, or are payable over the counters of the company at Montpelier. The Standard Oil Company, owning, as it does, the only pipe lines of any size entering the Indiana field, controls the price of Indiana oil. It can raise or lower it at will. It is said that in 1895, wishing to get possession of outstanding certificates harmful to its interests, it forced the price of Indiana and South Lima oil to $1.15 a barrel. Immediately it had accomplished its object, the price was gradually lowered until in the fall of 1896 it ranged between 57 and 61 cents. At all times within the past few years North Lima oil, though of the same quality as that from Indiana and South Lima, has sold at from five to ten cents a barrel more, for the reason that competition exists in the former district. The Pennsylvania and West Virginia oils, being of a better quality, bring from 47 to 58 cents more per barrel than the Indiana product.

The Cudahy Pipe Line, being of small capacity, can do little towards increasing the price of Indiana oil. It is a private line, constructed to relieve its owners (who, next to the Standard, are the largest producers in the Indiana field) from the power of the Standard, rather than to serve as a competitor to the latter company.

The real value of a barrel of crude Indiana petroleum, when one takes into consideration the manifold products derived from it, is nearly double its present market price of 58 cents. But with the output wholly in the power of a monopoly, which is commonly reputed to "know no scruples in its treatment of competitors," there is little chance for the Indiana producer to receive just value for that which he produces. At present he is wholly deprived of the benefits ever accompanying free competition. He must take his choice of staying out of the field or selling the product for the arbitrary price fixed by the one purchaser.

Use of Muriatic Acid in Old Wells.

A producing well often has to be overhauled and cleaned. Where the production has run down there have been in recent years several attempts to increase it by the use of hydrochloric (muriatic) acid, some of which have been quite successful. A well in the northwest quarter of section 4 (24 north, 13 east), Jackson Township, Wells County, operated by the Fry Oil Company, when three years and a half old, had a production of but five barrels daily. It was then treated with 148 carboys of acid, costing something over $400. In six days the acid was neutralized, and the well began pumping twenty barrels a day and kept it up for several months.

On the Schooley farm, in the southeast quarter of northwest quarter of section 29 (25 north, 12 east), Nottingham Township, Wells County, a well which in April, 1895, started at 150 barrels was down to ten barrels in June, 1896. Studebaker, Bennett & Co., of Bluffton, Indiana, then treated it with a carload of muriatic acid at a cost of $400. They let it stand for nine days and then cleaned it out, and it began yielding fifty barrels a day, which it kept up for six weeks; for the second six weeks it averaged thirty barrels daily, and by October 15 it was down to fifteen barrels. In both of the above wells the acid treatment was a success financially, but in several other wells in Adams and Wells Counties it has proven a failure. Where the porous stratum is rather coarse, the acid acts more freely on the dolomite and probably increases the flow for a while. Where the stratum is close-pored, a carload of acid does not affect the rock far enough distant from the well to cause much increase in the production.

Statistics of the Indiana Oil Field.

The production of oil in Indiana has gradually increased from 33,375 barrels in 1889, when the wells at Terre Haute first began yielding, to 4,659,290 barrels in 1896. In no year has the production diminished below that of the preceding year, though in 1896 the gain was but 272,850 barrels, or 6.2 per cent., whereas in 1895 it was 697,466 barrels, or 18.9 per cent. The lower price of oil and the general stagnation of business preceding the national election prevented many wells from being drilled in 1896 which would otherwise have been put down.

In the following table is shown the total production of petroleum in Indiana by months from 1891 to 1896. The largest production in any one month is seen to have been in May, 1896, when 442,490 barrels were produced:

TOTAL PRODUCTION OF PETROLEUM IN INDIANA FROM 1891 TO 1896, BY MONTHS.

[Barrels.]

MONTH.	1891.	1892.	1893.	1894.	1895.	1896.
January	6,171	15,841	111,824	259,000	300,568	371,430
February	5.981	18,946	96,025	232,107	230,559	335,053
March	5,159	24,794	134,549	282,376	310,303	381,680
April	4,973	26,184	146,493	287,330	352,077	390.297
May	5,757	31,033	186,939	321,502	397,001	442,490
June	8,136	40,888	209,616	333,479	403,569	437,628
July	10,809	49,203	221,666	327,349	434,376	428,413
August	11,603	56,109	248,353	345,031	420,132	407,990
September	16,500	66,034	245,615	319,588	409,169	405,106
October	19,029	95,699	252,568	339,424	393,153	345,662
November	20,801	129,270	245,607	304,030	373,789	327,826
December	21,715	144,067	236,038	337,450	361,436	314,715
Total	136,634	698,068	2,335,293	3,688,666	4,386,132	4,588,290

Adding to the 4,588,290 barrels, the amount transported by the Buckeye Pipe Line from the Indiana field, 71,000 barrels, the amount produced by the Northern Indiana Oil Company between September 17 and January 1, we have 4,659,290 barrels as the total product of the Indiana field for 1896.

It will be noted that the production in each of the winter months is less than in those of spring or summer. This is usually the case, there being, during the cold season, fewer wells drilled in and a smaller yield from those already finished. The shipments are greater than the production in winter and the price usually rises a few cents per barrel.

In the following table will be found a statement of the production of petroleum in Indiana from 1889 to 1896, inclusive:

PRODUCTION OF PETROLEUM IN INDIANA FROM 1889 TO 1896.

	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.
Total production (barrels of 42 gallons) . .	33,375	63,496	136,634	698,068	2,335,293	3,688,666	4,386,132	4,659,290
Total value at wells of all oils produced, excluding pipage . .	$10,881	$32,462	$54,787	$260,620	$1,050,882	$1,774,260	$2,807,124	$2,842,166
Value per barrel . . .	$0.32¼	$0.51⅛	$0.40	$0.37	$0 45	$0.48	$0.64	$0.61

NUMBER OF WELLS COMPLETED IN THE INDIANA OIL FIELD FROM 1891 TO 1896, BY MONTHS.

YEAR.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1891	.	. . .	. . .	. . .	. . .	. .	6	6	15	15	15	8	65
1892	11	13	18	13	17	19	17	30	25	52	33	47	295
1893	20	30	31	36	45	47	47	55	27	72	56	76	542
1894	90	103	103	80	110	107	84	123	100	107	97	85	1,189
1895	61	45	81	111	122	153	132	140	129	106	102	85	1,267
1896 . . .	76	90	86	136	148	151	113	121	70	57	66	66	1,180
Total . .	. . .	. . .	. .	. . .	. . .	. . .	. .	. .	. . .	. . .	.	. . .	4,538

On January 1, 1897, there were 3,442 wells producing oil in the Indiana field, so that 1,096 of those completed had either proven dry holes or had ceased to yield oil in quantity sufficient to pay for pumping.

INITIAL DAILY PRODUCTION OF NEW WELLS IN INDIANA OIL FIELD FROM 1891 TO 1896, BY MONTHS.

[Barrels.]

MONTH.	1891.	1892.	1893.	1894.	1895.	1896.
January	. . . . .	342	1,020	2,361	2,132	1,557
February	. . . . .	250	913	2,935	1,413	1,875
March	. . . . .	289	2,805	3,395	2,504	2,090
April	. . . . .	316	4,135	3,175	3,473	2,820
May	. . . . .	506	3,155	4,450	3,035	3,195
June	. . . . .	545	5,595	4,886	4,923	3,155
July	253	595	3,880	3,530	3,067	2,335
August	135	1,295	4,184	3,435	2,760	2,650
September	875	2,145	2,055	3,149	3,175	1,700
October	330	4,155	3,442	3,455	2,651	1,500
November	390	3,050	2,305	3,323	2,560	1,395
December	175	3,160	2,968	2,654	2,025	1,100
Total	2,158	16,647	36,457	40,748	33,718	25,372

One feature of the oil industry which has come into common use, and which should be abandoned, is that of giving the initial output of a well rather than its settled production after 30 or 60 days. Because a well starts out at 100 to 250 barrels a day is no sign that its total production will be a large one. From the well records given in the detailed account of the Indiana field, it will be noted that the production falls rapidly. In general it may be said that a 50-barrel well will be down to 10 barrels in two months and to five barrels in a year. A fifty-barrel well is a fair average well for the entire Indiana field, the average production of which is about four barrels per well per day. A well that starts off at 150 to 250 barrels gets down to the average in time, the only difference being that the oil bearing stratum which the bore has pierced is a little more porous than in the one yielding 50 barrels.

Average Production of Indiana Field.

While the waste in the oil field of the State has not been proportionally as great as that which characterized the early days of the natural gas area, it is even yet far above what it ought to be; the waste of both gas and oil being in the course of a year an enormous one. Many wells are drilled which yield both gas and oil; and the drillers, seeking only the latter, allow the former to escape or burn it freely in flambeaux and other lights. Again, where only gas is found the well is often abandoned without being properly capped, and much valuable fuel is thereby lost.

Waste in the Oil Field.

Moreover, one can not pass through the oil field without noting that every pool and stream of water is covered with oil, thousands of barrels being allowed to go to waste through leakage and overflow of tanks; overflow of wells when first shot; or through the oil passing off in quantity with the salt water flowing from the tanks. With these two fuels it is like everything else which is abundant for a time; satiety begets careless and excessive use. The time will come, and that before many years, when the stored reservoirs of these great resources will have been drained, and only the dregs be left as a reminder of the plenty that has been.

As has been already noted, it is the small operator who does most of the "wild-catting." A man with a few hundred dollars of surplus money gets the "oil fever," believes there is oil to be found in his vicinity, and proceeds to organize a company among his neighbors or fellow-townsmen. The bore is sunk, and if it proves dry it serves the purpose of marking a tract which is thereafter avoided. If it be a gas well its output may be used as fuel if that commodity is not already too abundant. If it be a fair producing oil well, and yet some distance from the main field, the company will have difficulty in getting a pipe line to carry away the product; and, not wishing to assess the members for another well, the chances are that the one bored

The Small Operator.

will be finally plugged, and the only benefits derived from its boring will be the marking more clearly the limits of the productive field. The average "wild-catter" is satisfied if he makes $5,000 in the oil business. If a good well is struck close to the limits of territory already producing, it and the lease on which it is located are usually sold to a company with larger means. This company puts down six or eight bores, and if they are fair or good producers it, in time, usually sells to a still larger company, like the Standard or the Northern Indiana, for a good profit. The usual selling price in the Indiana field for an oil property consisting of a lease of eighty to one hundred and sixty acres, with three to eight wells, having a settled production, is $300 a barrel for the average daily production. More money has been made by Indiana operators in thus partially developing and selling leases to the larger companies than in any other way.

The Indiana Field as a Whole.

From a careful study of the Indiana oil field, and conversations with the leading operators therein, it is the writer's opinion that nearly, if not quite, as much money is being spent in the field each year, as is gotten out of it. Some men who understand fully the details of oil production and are following the business of producing as a vocation, are making money in large amounts, but many who enter the field for purely speculative purposes are losing it. The principal reason for this is, that there is no certainty of striking oil at any one place, even on the best proven territory. But little reliance can be put in the size or shape of any so called "pool" in Indiana, as, on account of the deep drift covering the surface, the anticlines and the synclines of the Niagara and Trenton rock can be determined only by the drill. All wells are, therefore, risky investments. In the words of a leading operator, "Each new bore is practically a wildcatting experiment—a lottery, where you pay $1,500 to $2,500 a chance, and sometimes draw a big prize, sometimes a fair one, and often a blank." As the spirit of speculation is ever rife among the American people, individuals are plentiful who are willing to accept the chances at the prices given, and so each year sees many wild-cat bores go down, a large proportion of which are losing investments.

As the output of the older wells is constantly diminishing, it is necessary that a large number of new ones be put down each year to prevent the annual production from dropping. While in 1896 the annual production was increased, the new output did not increase proportionally the average production of the field, and the older operators believe that unless a large area of virgin territory is soon located the average will soon drop from four barrels to three, or even less, per well.

Up to the present the farmers who have owned the land on which producing wells were bored are the ones who have been most benefited by the discovery of oil in Indiana. They had everything to gain and nothing to lose in leasing their property. Some of the first operators in the field after losing money finally regained it and much more by staying with the business and developing and selling leases in the manner already mentioned, while a large number of them still possess valuable producing property. The Standard Oil Company has also, doubtless, made much money in the Indiana field both as a producer and a purchaser.

Finally, it may be said that an investor who wishes to become a *bona fide* producer can yet make money in the Indiana field if his property is managed on strictly business principles. To such an investor we would say: Put your money in a partially developed or good prospective lease within the known productive limits. Remember that one large well will not make any man a fortune; twenty small ones may in time. The yield of the large one will in time become much less; that of the twenty small ones will hold out for a long time. Connect the twenty wells to one power and put a good man in charge of it Pump steadily so as to get all the oil possible. Keep your drilling tools, your lead pipes and your pumping machinery in good condition. Be saving of fuel and especially look out for overflow and waste of your production. Let other people do the wild-catting, and if you desire to make new investments follow where they lead.

COMPOSITION OF INDIANA COALS.

BY W. A. NOYES.

Collection of Samples.—In the examination of any mineral which is to be sold or used for commercial purposes the selection of samples is of very great importance. In many cases it is possible to select a sample in such a manner that the analysis will show results which are very much better than the real average of the commercial product. For this reason, in the present study of the composition of Indiana coals, careful attention was paid, at first, to the selection of samples which should represent as nearly as possible the commercial product of the State. The samples, with one exception, were taken in the mines from the face of the vein, beginning at the top and cutting down at several places in such a manner as to secure an average sample of the coal. These larger samples were then broken into small pieces and "quartered" down to secure the smaller sample, which was submitted for analysis. This smaller sample was then placed in a sealed bottle and was sent to me in that form.

Samples 1–11, inclusive, were collected by the Assistant Mine Inspector, James Epperson. Samples 12–19, inclusive, were collected by the Mine Inspector for the State, Robert Fisher. The samples were taken in the mines by these gentlemen, and not by the owners of the mines. Sample No. 20 was an office sample sent by the Superintendent of the company, as the mine was not in operation at the time.

Samples 21–27, inclusive, are samples of Pittsburgh and West Virginia coals, furnished through the kindness of Mr. Henry Immerhart, of the Marmet Company, Cincinnati, Ohio. These samples were taken from the cars in Cincinnati, and were analyzed for the purpose of comparing their composition with that of Indiana coals.

DESCRIPTION OF COALS.

1. Vanderburgh County. Sunny Side Coal & Coke Co., Evansville. Shaft, 280 ft. deep; vein, 4 ft. 6 in.; roof, black slate; floor, fire clay, 3 ft. thick.

2. Warrick County. Deforest Mine, three miles west of Boonville, on "Air Line" R. R. Shaft, 65 ft. deep; vein, 6 ft.; roof, black slate; floor, fire clay.

3. Knox County. Edwardsport Coal Mine, worked by Edwardsport Coal and Mining Co. Vein, 4 ft. 6 in.; roof, black slate, 35 or 40 ft. thick; floor, fire clay.

4. Knox County. Bicknell Mine, on I. & V. R. R., owned by the Bicknell Coal Co. Shaft, 92 ft. deep; vein, 4 ft. 2 in.; roof, gray slate.

6. Daviess County. Cabel & Kaufman Mine, three miles southwest of Washington. Shaft, 86 ft. deep; vein, 4 ft.; roof, soft gray slate; floor, soft white fire clay.

7. Sullivan County. Star City Mine, two and a half miles east of Shelburn. Shaft, 100 ft. deep; vein, 5 ft.; roof, black slate; floor, "Black Jack" or "bone coal," underlaid with hard fire clay, merging into sandstone.

8. Sullivan County. Alum Cave Mine. Shaft, 45 ft.; vein, 5 ft. 6 in.; roof, black shale; floor, same as last.

9. Greene County. Buckeye or Fluhart Mine, owned by the Linton Coal and Mining Co., one and a half miles southwest of Linton, on the I. & V. R. R. Shaft, 92 ft.; vein, 5 ft.; roof, gray slate.

10. Greene County. Summit Mine, owned by the Dugger & Neil Coal Co. Two miles west of Linton on the I. & V. R. R. Shaft, 100 ft.; vein, 5 ft. 2 in.; roof, gray shale.

11. Greene County. Island City Mine No. 1, owned by the Island City Coal Co. One and one-half miles south of Linton. Shaft, 66½ ft.; vein, 5 ft.; roof, gray shale.

12. Vigo County. Ray Mine, owned by the Vigo County Coal Co., at Seeleyville. Vein, 7 ft. thick, carrying two thin slate bands, dividing it into three nearly equal parts. Slate easily separated, and other impurities readily removed.

13. Clay County. Gart, No. 5 Shaft, Cardonia, owned by the Brazil Block Coal Co. Vein, 3 ft. 6 in.; roof, gray bituminous shale; floor, 6–12 in. of fire clay, underlaid by dark shale.

14. Clay County. Brazil Block, No. 1 Shaft, owned by the Brazil Block Coal Co. Vein, 3 ft. 10 in.; roof, white shale, cut by irregular "slips" or clay veins; floor, fire clay, 3–5 ft. thick.

15. Clay County. Eureka Mine No. 1, owned by the Eureka Block Coal Co. Vein, 3 ft. to 4 ft. 6 in.; roof, gray bituminous shale; floor, 6–12 in. of fire clay, underlaid by a dark shale.

16. Clay County. Crawford Mine No. 3, owned by the Crawford Coal Co., of Brazil, Ind. Roof and floor, as last.

17. Clay County. Columbia No. 2 Mine, block coal, owned by Teller, McCleland & Co.

18. Owen County. Lancaster No. 4 Mine. Vein, 3 ft. 6 in. to 4 ft. 10 in.; roof, soft shale; floor, fire clay, 2 in. to 3 ft. thick. Fair representative of the coal mined in the vicinity of Clay City, Clay County.

19. Parke County. McIntosh No. 1 Mine, near Diamond, owned by I. McIntosh & Co., Brazil, Ind. Block coal.

20. Parke County. Cox No. 3 Mine, bituminous, owned by the Brazil Block Coal Co., Brazil, Ind. Office sample selected by the Superintendent. Vein, 6 ft.; roof, dark shale, overlaid by sandstone; floor, thin fire clay and shale or slate.

21. Pittsburgh Coal. Beck's Run, first pool coal, Hays Coal Co.

22. Pittsburgh Coal. Anchor, fourth pool coal, Beaumont Coal Co.

23. Pittsburgh Coal. Caledonia, fourth pool coal, T. J. Wood.

24. Pittsburgh Coal. Stony Hill, fourth pool coal, John D. Nixon.

25. Pittsburgh Coal. Little Redstone, fourth pool coal, Little Redstone Coal Co.

26. West Virginia Coal. Raymond coal, The Marmet Smith Coal and Mining Co., Raymond City, W. Va.

27. West Virginia Coal. Belmont coal, Belmont Coal Co.

METHODS OF ANALYSIS.

Moisture.—One gram of the coal was dried in a porcelain crucible in a toluene bath (at about 105° C.) for one hour. Experiments made in this laboratory by Mr. W. E. Burk have shown that the loss of volatile combustible matter when a coal is heated at 100° in a current of dry air for one hour is so small as to be insignificant. (See Report of the Indiana Academy of Science for 1896.)

Ash.—The coal in which the moisture was determined was heated over a Bunsen burner, at first with a very low flame, till the carbon was completely burned.

Fixed Carbon.—One gram of fresh coal was placed in a platinum crucible 34 mm. in diameter and 35 mm. high, and heated for seven minutes over the full flame of a Bunsen burner. The crucible was placed on a platinum triangle with its bottom 7 cm. above the top of the burner, and the flame, when burning free, was 25 cm. high. This careful description of method is given, because the methods used by different chemists are not the same, and the results depend, to a considerable extent, on the method used.

The fixed carbon is calculated by subtracting from the coke left by the treatment described, the ash, as found above. Since the iron remains chiefly as the sulphide in the coke and as ferric oxide in the ash, this method of calculation is not strictly accurate, but so long as methods of determining fixed carbon vary as they do, it would be a useless refinement to employ a more correct method of calculation.

Volatile Combustible Matter.—The loss of weight in determining fixed carbon, less the moisture, gives the volatile combustible matter. This volatile combustible matter may be assumed to contain about one-half of the sulphur. As the volatile combustible matter is determined by difference, the sum of the four substances, mentioned above, must always equal one hundred per cent. The sulphur is partly included in the volatile combustible matter, partly replaced by oxygen in the ash, and partly, though usually to only a very small extent, remains in the ash in the form of sulphates.

Sulphur.—This was determined by Eschka's method. One gram of the coal was mixed with one and a half grams of a mixture of one part of sodium carbonate with two parts of magnesium oxide, a small amount of the mixture being placed on top. The whole was heated in a platinum crucible over an alcohol lamp till the carbon was completely burned. After cooling, one gram of ammonium nitrate was mixed in and the mixture heated again for ten minutes. The residue was then treated with successive portions of hot water and thoroughly washed. The filtrate was acidified with 10^{cc} of dilute hydrochloric acid (1:4 by volume), heated to boiling and 10^{cc} of a ten per cent. solution of barium chloride added very slowly. After digesting, hot, till the solution settled clear, quickly, after stirring, the barium sulphate was filtered off, ignited and weighed. A correction was applied for the amount of sulphur found in the reagents.

Heating Effect.—The best method of determining the heating effect of coals is to burn them in an autoclave in an atmosphere of compressed oxygen. The time and money at our disposal did not, however, permit the use of that method. In order to secure some basis for an approximate comparison of the heating effect of the coals, use was made of what is known as Berthier's test. This was carried out as follows: One gram of the coal was intimately mixed with forty grams of litharge and the mixture was put in a Battersea C crucible, seven and a half centimeters deep and four and a half centimeters in internal diameter. The covered crucible was then placed in a *hot* gas furnace and heated for fifteen minutes. The crucible was then taken out, tapped to collect the lead, cooled, broken, and the lead button cleaned and weighed.

The determination is based on the supposition that the lead is proportional to the amount of oxygen required for the complete combustion of the fuel, and that the latter is proportional to the heating effect of the fuel. Neither assumption is strictly true. In accordance with these assumptions, one gram of lead should correspond to about 234 calories of heat. During the spring of 1895 Mr. J. R. McTaggart and Mr. H. W. Craver undertook, at my suggestion, in the laboratory of the Rose Polytechnic Institute, a comparison of Berthier's test with the results of the calculation of heating effect from analyses and with the results obtained by burning the same coals in Hempel's Calorimeter. The results and a discussion of the methods used are published in the Journal of the American Chemical Society, volume 17, page 843. The following table is reprinted from that Journal:

	New Pittsburgh A.	New Pittsburgh B.	Lancaster.	Brazil.	Shelburn.	Shop.
Moisture	6.83	5.89	12.66	8.96	8.63	2.36
Volatile combustible matter	39.92	42.23	37.44	34.49	38.82	31.11
Fixed carbon	39.93	40.40	47.22	50.30	43.45	42.44
Ash	13.31	11 48	2.68	6.22	9.05	24.09
Carbon	62.88	65.26	71 41	70.50	66.86	57.32
Hydrogen	5.07	5.17	5.56	4.76	5.30	4.56
Nitrogen	1.01	1.17	1.54	1.36	1.50	1.44
Oxygen	13.06	13.25	18.42	16.29	15.69	9.93
Ash (corrected)	17.98	15.15	3.07	7.09	10.65	26.75
Sulphur	7.46	5.88	0.62	1.39	2.57	4.25
Iron, calculated	6.53	5.14	0.54	1.22	2.25	3.72
Calories per gram, calculated C	5081.00	5272.00	5770.00	5696.00	5402.00	4632.00
Calories per gram, calculated . . . . H	991.00	1011.00	939.00	784.00	962.00	956.00
Calories per gram, calculated . . . . S	161.00	127.00	13.00	30.00	55.00	92.00
Calories per gram, calculated . . . . Fe	103.00	81.00	9.00	19.00	36 00	59.00
Total	6336.00	6491.00	6731.00	6529.00	6455.00	5789.00
Difference, per cent	+2.60	+1.20	+0.40	—4.60	—1.20	—1.20
Calories per gram, Berthier's test, factor 268.3	6307.00	6471.00	6831.00	6689.00	6461.00	5726.00
Difference, per cent	+2.10	+0.90	+1.90	—2.30	—1.10	—1.40
Calories per gram, calorimeter	6175.00	6415.00	6703.00	6846.00	6532.00	5806.00

It will be seen from this table that in order that the results of Berthier's test should agree with the results of the calorimeter, which were undoubtedly very nearly correct, it was necessary to use an empirical factor of 268.3 calories per gram of lead. It was hoped, when the present work was begun, that the same factor could be used. On examining the results obtained, however, it was found that for the Brazil block and Lancaster coals values calculated with this factor were about ten per cent. too low. Assuming that the total combustible matter in these coals is of the same composition as that in the same coals examined by Messrs. McTaggart and Craver a factor of 300 calories per gram of lead must be used. The difference is due partly to the fact that the litharge used in the present series contained a little red lead and partly, probably, to slight differences in the manipulation and in the temperature of the furnace. Of course, under these circumstances, the results can not be considered as very reliable. The table is given with a good deal of hesitation and only as giving approximately the heating effects of the coals. Differences of less than two or three per cent. in the heating value should not be taken as proving that one coal is better than another.

The same test was applied to the Pittsburgh coals, but the results differed so much from the results obtained by Professor N. W. Lord, of Ohio University, by burning similar coals in a calorimeter that it was clear that the results obtained by the litharge test for these coals are worthless unless a different factor is used.

The total combustible matter in the coals may also be used to calculate the heating effect. If, in the table given above, one-half of the sulphur is subtracted from the total combustible matter and the heating effect as determined by the calorimeter is divided by the remainder, we obtain the following values as the heating effect in calories of one per cent. of combustible matter:

New Pittsburgh A	81.12 calories.
New Pittsburgh B	80.50 calories.
Lancaster	79.43 calories.
Brazil	81.41 calories.
Shelburn	80.66 calories.
Shop	81.29 calories.
Average	80.73 calories.

A similar calculation from the analyses and calorimetric determinations of the heating effect of fifteen Pittsburgh coals, as given by Professor N. W. Lord, of the University of Ohio, gives, on the average, 80.78 calories.

We may, therefore, use the following rule for the calculation of the heating effect: *Subtract from the per cent. of total combustible matter one-half of the per cent. of sulphur and multiply the remainder by 80.7.*

It is believed that for Indiana and Pittsburgh coals of the class examined, the results of such a calculation will very rarely differ by more than two per cent. from the heating effect as determined by careful tests with a calorimeter, and that in most cases the agreement will be closer than that. This close agreement may be due, in part, to the fact, as shown by the analysis, that the oxygen in other forms than moisture varies only between very narrow limits and is very nearly the same for both the Indiana and Pittsburgh coals. The amount is in most cases seven to eight per cent. Without a similar comparison with a calorimeter it would not be safe to apply the formula given to the calculation of the heating effect of coals containing a different amount of oxygen.

All of the calculations and results given in this paper are based on the supposition that the coal is burned to vapor of water at 212° F. If, as is often done, the results were calculated on the supposition that the coal is burned to liquid water at ordinary temperatures, they would be from 275 to 300 calories per gram higher. As in actual use the products of combustion always escape as carbon dioxide and vapor of water, the lower values correspond to the conditions of use.

Evaporative Effect.—To convert one kilogram of water into one kilogram of steam, from and at 212° F., requires 536 calories of heat. If the heating effect is divided by 536, therefore, we obtain the evaporative effect in kilograms of water per kilogram of coal or in pounds of water per pound of coal.

INTERPRETATION OF RESULTS AND COMPARISON OF COALS.

Moisture.—The moisture present in coal lessens its value partly by lessening the amount of fuel contained and partly because heat is required to convert the water into steam when using the fuel. For the latter reason a difference of ten per cent. in the amount of moisture will cause a difference of about eleven per cent. in the value of coals for heating purposes.

One of the most notable differences between the Indiana and Pittsburgh coals is the larger amount of moisture in the former. In the Indiana coals the moisture varies from six to fourteen per cent., while in the Pittsburgh coals it is two per cent. or less. That the difference is characteristic and not merely due to some accident about these samples is fully established by many analyses made by others.

Volatile Combustible Matter and Fixed Carbon.—The value of a coal is, in most cases, increased by an increase of the fixed carbon as compared with the volatile combustible matter. An increase in the volatile matter causes the coal to burn with a smoky flame and renders it more difficult to secure complete combustion. If completely burned, however, this volatile matter gives approximately the same amount of heat as the same weight of fixed carbon. For boilers and furnaces, where proper appliances can be used to secure complete combustion, a relatively large amount of volatile matter is, therefore, not to be considered objectionable. For the manufacture of coke and for domestic use, however, a high per cent. of fixed carbon is desirable.

The amount of fixed carbon in proportion to volatile combustible matter is considerably greater in the Pittsburgh coals than in most of the Indiana coals.

Of the Indiana coals the block coals show a larger proportion of fixed carbon than the coals commonly called in this State "bituminous" coals. It should be remembered, however, that in the proper meaning of the term all coals mined in this State are bituminous.

Ash.—This lessens the value of a coal by decreasing the amount of fuel contained and because of the labor required to handle it after the coal is burned. The ash of the Indiana coals compares favorably with that of the Pittsburgh coals.

Sulphur.—The sulphur of the coals is mostly in the form of iron pyrites. While this iron pyrites gives some heat when burned, the sulphur is always considered objectionable in a coal. A high per cent. of sulphur renders a coal unfit for the use of the blacksmith or for the manufacture of iron. It also causes a coal to slack and disintegrate when exposed to the weather, and the heat generated by its oxidation in moistened coal may cause the coal to take fire spontaneously. The sulphide of iron formed from the iron pyrites may form troublesome clinkers in a furnace and may sometimes attack and destroy the grate bars.

While the amount of sulphur in a few of the coals is undesirably high, most of the coals analyzed compare favorably with those from other localities.

Theoretical Heating and Evaporative Effect.—The commercial value of a coal depends primarily on its heating effect, while, if complete combustion is secured, practical boiler tests and furnace tests will give very nearly the same relative value for coals as those determined by calorimetric experiments, it often happens that the conditions of use are imperfect and that practical results will vary considerably from the theoretical values. In any case the heat obtained in practice can never equal the theoretical values. In use for boilers, for instance, it must be considered as very successful practice if sixty or seventy per cent. of the theoretical evaporative effect is secured. It is safe to say that in the vast majority of cases the efficiency of boilers is below fifty per cent. Better results may be obtained, partly by the introduction of proper stoking devices or other appliances to secure complete combustion of all parts of the coal, partly by selection of a coal with regard to the character of the individual furnace.

Number.	COUNTY.	NAME OF COAL AND OWNERS.	Total Combustible Matter	Volatile Combustible Matter.	Fixed Carbon.	Moisture.	Ash.	Sulphur.	Heating Effect—Calories per Kilogram, Calculated.	Heating Effect—Calories per Kilogram, Berthier's Test.	Evaporative Effect—Pounds of Water per Pound of Coal.
1	Vanderburgh	Sunny Side Coal and Coke Co , Evansville, bituminous	86.73	38.59	48.14	6.44	6.83	1,85	6924.	6759.	12.9
2	Warrick	Deforest Mine, bituminous	84.16	39.09	45.07	6 08	9.76	2.14	6705.	6339.	12.5
3	Knox	Edwardsport Coal. Edwardsport Coal and Mining Co., bituminous	82.03	36.00	46.03	8.75	9.22	3.08	6495.	6345.	12.1
4	Knox	Bicknell Mine, Bicknell Coal Co., bituminous	83 76	35.22	48.54	7.61	8.63	1.67	6692.	6489.	12.5
5	Pike	Lauder-Wooley Coal Co., Petersburg, bituminous.	85.31	43.51	41.80	6.87	7.82	3.56	6741.	. . .	12.6
6	Daviess	Cabel & Kauffmann, bituminous	87.15	37.99	49.16	6.50	6.35	1.85	6958.	6961.	13.0
7	Sullivan	Star City, bituminous	87.30	38 53	48.77	9.40	3.30	1.23	6995.	7002.	13.0
8	Sullivan	Alum Cave, bituminous	84.77	42.60	42.17	6.49	8.74	3.18	6712.	6894.	12.5
9	Greene	Buckeye or Fluhart Mine, Linton Coal and Mining Co., bituminous	86.79	35.69	51.10	7.81	5.40	0.72	6974.	6618.	13.0
10	Greene	Summit Mine, Dugger & Neil Coal Co., bituminous . .	87.54	35.30	52.24	7.44	5.02	0.61	7041.	6852.	13.1

Number.	COUNTY.	NAME OF COAL AND OWNERS.	Total Combustible Matter.	Volatile Combustible Matter.	Fixed Carbon.	Moisture.	Ash.	Sulphur.	Heating Effect—Calories per Kilogram, Calculated.	Heating Effect—Calories per Kilogram, Berthier's Test.	Evaporative Effect—Pounds of Water per Pound of Coal.
11	Greene.	Island City Mine, No. 1, Island City Coal Co., bituminous.	86.47	35.97	50.50	7.12	6.41	0.84	6944.	6819.	13.0
12	Vigo.	Ray Mine, Seeleyville, Vigo County Coal Co., bituminous.	84.46	40.25	44.21	7.57	7.97	4.01	6656.	6762.	12.4
13	Clay	Gart, No. 5 Shaft, Brazil Block Coal Co., block.	85.27	36.11	49.16	11.20	3.53	0 62	6856.	6774.	12.8
14	Clay	Brazil Block, No. 1 Shaft, Brazil Block Coal Co., block	85.12	45.16	49.96	13.82	1.06	1.47	6810.	6888.	12.9
15	Clay	Eureka Mine No. 1, Carbon, Eureka Block Coal Co., block.	86.74	36.32	50.42	9.80	3.46	0.34	6985.	7050.	13.1
16	Clay	Crawford, No. 3 Mine, Crawford Coal Co., block	84.58	36.34	48.23	11.26	4.16	0.56	6803.	6858.	12.7
17	Clay	Columbia, No. 2 Mine, Teller, McCleland & Co., block.	89.52	36.75	52.77	7.47	3.01	0.57	72.02	7344.	13.4
18	Owen	Lancaster, No. 4 Mine, semi-block.	83.85	36.45	47.40	12.73	3.42	0.55	6744.	6636.	12.6
19	Parke	McIntosh, No. 1 Mine, I. McIntosh & Co., block . .	87.70	36.69	51.01	8.21	4.09	0.95	7039.	7008.	13.1
20	Parke	Cox, No. 3 Shaft, Brazil Block Coal Co., bituminous . .	88.33	41.88	46.45	6.49	5.13	2.93	7009.	6897.	13.1

21	Pittsburgh Coal	Beck's Run, First Pool, Hays Coal Co	96.06	36.01	60.05	2.09	1.85	0.64	7726.	....	14.6
22	Pittsburgh Coal	Anchor, Fourth Pool, Beaumont Coal Co.	89.84	35.30	54.54	1.30	8.86	0.45	7230.	....	13.5
23	Pittsburgh Coal	Caledonia, Fourth Pool, T. J. Wood	90.26	35.22	55.04	1.35	8.39	0.69	7256.	....	13.5
24	Pittsburgh Coal	Stony Hill, Fourth Pool, John D. Nixon	92.74	35.46	57.28	1.11	6.15	0.56	7462.	....	13.9
25	Pittsburgh Coal	Little Redstone, Fourth Pool, Little Redstone Coal Co	91.08	35.88	55.20	0.98	7.94	0.82	7316.	....	13.7
26	West Virginia Coal	Raymond, Marmet Smith Coal and Mining Co.	91.16	40.14	51.02	3.20	5.64	2.25	7266.	....	13.6
27	West Virginia Coal	Belmont, Belmont Coal Co., Belmont, W. Va	90.04	37.84	52.20	1.45	8.51	0.46	7248.	....	13.5

SOME NOTES ON THE BLACK SLATE OR GENESEE SHALE, OF NEW ALBANY, IND.

BY HANS DUDEN.

The great uncertainty existing among scientists about the age of the New Albany black slate has induced me to study with interest this formation. The few facts I observed during the years 1894 and 1895 more than paid me for the time and labor spent, and I hope that the following will help to give a better understanding of this Devonian formation.

The black slate is well exposed in all water courses near New Albany and can be best studied along the Ohio River, beginning at the mouth of Silver Creek and continuing five miles below town; also along the Silver Creek bed, from a mile above Blackiston's mill down to its mouth, and in a good many places along Falling-run Creek. The deep bed, cut by the waters of Silver Creek into the slate, offers, perhaps, the best exposure, and reaches in many places to a depth of eighty feet. Tho total depth of the slate, according to Dr. Clapp's borings, is 104 feet at the foot of the knobs.* I also refer to Mr. Cubberly's paper† in which he gives the thickness of the slates at Salem at 103 feet as revealed by the drill.

The slate has a black to bluish gray color when freshly broken, but changes, after being exposed to the air, to light gray or drab. It becomes brittle and splits into thin laminæ and at the same time a whitish or yellowish salt weathers out, sometimes several feet in thickness, and forms the so-called "copperas banks."

The year 1895, with extremely low water during the summer months, was very suitable for my investigation. When coming from Jeffersonville, along the dry Ohio bed, the Corniferous limestone formation stops very suddenly about 200 feet above the mouth of Silver Creek and the black slate begins without any intermediate change. The careful observer will at once notice two different systems of cuts perpendicular to the layers of the stratum. One set of joints runs nearly from north to south and is more prominent with openings of two to three inches at the surface. The other system of joints is less marked and the slits run from west northwest to east southeast. The origin of the regular jointed structure is still doubtful; some believe it to be caused by shrinkage during the drying process, others, by the uplifting of the strata, and Prof.

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*Geological Report of Indiana, 1873, page 158.

†Eighteenth Report, Ind. Geol. Surv., 1893, 219, Table XV.

King thinks it to be a physical phenomenon and terms it a crystalline polarity depending on the secular variation of the magnetic meridian.

At many exposures of the black slate the jointed structure causes it to break in the above mentioned joints and the waters have worn the slate so that from a distance it resembles fortifications.

The lamination of the slate is caused by pressure. Tyndall long ago demonstrated that homogeneous, fine grained bodies under high pressure become of a slaty cleavage. The finer the grains, the thinner the laminæ, even material like paraffine, wax and so on, represent a scaly structure when taken from a hydraulic press.

Pyritic iron is evenly distributed throughout the whole formation as roundish concretions, as well as in particles in the form of dust, visible only with a microscope. Cubical, as well as needle-shaped crystals, are found, while some of the concretions have a radiated structure.

CHEMICAL COMPOSITION.

To give a full explanation of the "black slate" we have to consider also the chemical composition of the formation. Plainly spoken, it is sand in the form of very fine grains, cemented together by ferric sulphide, and this mixture is evenly saturated with the residues of plants (and perhaps animals) in the form of carbon and bitumen.

The following are the results of analyses of the slate taken from different localities near New Albany:

I.

Water expelled at 100° C	0.50
Volatile organic matters	14.16
Fixed carbon	9.30
Silica	50.53
[*]Pyritic iron and alumina	25.30
Calcium oxide	0.09
Magnesium oxide	0.12
	100.00

II.

Water expelled at 100° C., during four hours		0.56
Volatile organic matters	14.30	23.60
Fixed organic matters	9.30	
Silicates insoluble in HCl		65.43
Ferric oxide		8.32
Calcium oxide		0.09
Magnesium oxide		0.12
Sulphur		2.08
		100.00

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[*] The amount of pyrite and alumina changes considerably in different layers. This piece had 10.367 per cent. iron pyrite and 14.933 per cent. alumina.

The sand in such a fine condition is certainly a marine deposit The sea waters always contain a small amount of sulphate of lime and magnesia, which reacts on the iron oxide of the sea bottom. The resulting ferrous sulphate was reduced to ferric sulphide (pyrite) by the decaying organic matters, and we therefore find it very often replacing fossils. The carbon of the slate is so thoroughly intermingled with the sand that we can not explain it otherwise than by the theory that the organisms of this sea were deposited with the mud. Dittmar's Report on the Composition of Ocean Waters (1884), from seventy-seven complete analyses of different sea waters, gives as an average composition 6.410 per cent. of sulphuric acid in ocean water salts. These are the results of an extensive investigation made on H. M. S. Challenger. The high percentage of sulphuric acid fully explains the origin of the enormous quantities of pyritic iron contained in this slaty Devonian formation. The nodular as well as the fine grained pyrite (iron disulphide) had their origin in the above explained way, and it is my opinion that soft-bodied shell-less mollusks were totally replaced by the cubical crystallized or radiated iron disulphide. By observing a piece of the slate under a microscope with good light, one is astonished to find the piece glittering with the dust of this iron ore. When we expose this rock to the oxidizing influence of air and rain, the water and oxygen combine with the pyritic iron according to the following formula:

$$FeS_2 + 8\,H_2O + 7\,O = FeSO_4 + 7\,H_2O + H_2SO_4.$$

Pyrite + 8 water + 7 oxygen = iron sulphate (copperas) + 7 water + sulphuric acid.

The water-soluble iron sulphate is leached out by drainage water, and the free sulphuric acid reacts on the sand forming with silicate of alumina, aluminium sulphate, both of which salts occur in the so-called copperas banks of Silver Creek in considerable amounts. The free sulphuric acid has also a tendency to oxidize to carbonaceous matter of the slate, and the result is a light gray or drab-colored disintegrated mud. The oxidizing process has changed the bodies to their original forms, namely, sand and iron sulphate, the carbon being lost by oxidation.

An analysis of the salt weathered out on Silver Creek gave the following result:

Water expelled at 100° C	8.20
Water expelled by ignition	45.06
Iron oxide	20.54
Sulphuric acid	24.70
Matter insoluble in water, admixed slate	1.50
	100.00

We take up next the last and most interesting constituent, the carbon, which has already been mentioned as being the reducing agent which brings about the change of the sulphate of iron into the disulphide.

When a covered crucible filled with freshly pulverized slate (passed through a sieve of eighty meshes to the inch) is subjected to a Bunsen burner a great part of the carbon goes off in the form of inflammable vapors. On taking off the lid an asphalt like coating covers it on the inside. The residue which represents the fixed carbon is changed in color into a blue-black. By repeating the same experiment without any cover and giving the crucible a somewhat inclined position, stirring from time to time with platinum wire, all the carbon is oxydized and the light colored silicate remains.

In trying to extract the volatile components of the slate by solvents I did not succeed. Ether, alcohol, benzine, benzole, coal oil, chloroform, all gave the same negative result.

Dry, destructive distillation produces a blackish looking oil, an ammoniacal water and gas of high illuminating properties. This oil contains chiefly bodies of the paraffine series, and yields by redistillation and refining hard paraffine as well as fluid paraffine oils fit for many industrial uses.

The tendency of application of high temperature on organic substances is to break them up into their elements. Dry, destructive distillation produces complex compounds by rearrangements of the atoms before complete dissociation is reached. The degree of temperature employed is of importance, each elevation resulting in new compounds not possible at a lower temperature. It is, therefore, possible to obtain very different results by applying different temperatures during the distilling process. When the slates are thrown into a red-hot iron still and kept red hot, the greater part of the products of distillation will consist of gas. By applying a heat of perhaps 600° F. under atmospheric pressure a considerable amount of oil is obtained, and by distilling at twenty-four inches vacuum at 400° F. all the hard paraffine goes into the condenser unchanged without "cracking," as it is termed.

Hunt, in his chemical and geological essays, gives an analysis of black pyroschist equivalent to the Genesee from Bosanquet on Lake Huron. By ignition in a closed vessel it lost 12.4 per cent., the residue being black, and not calcareous.

A portion in fine powder was digested for several hours with heated benzole, which took up .8 per cent. of brown combustible matter. The residue carefully dried at 200° F. and subjected to dry, destructive distillation resulted in 11.3 per cent., and, by following calcination, 11.6 per cent. additional. By destructive distillation, 4.2 per cent. of oily hydrocarbon, and a large percentage of gas, and some ammoniacal water were obtained.

PREVIOUS EXPERIMENTS IN UTILIZING THE BLACK SLATE.

Referring to the Geological Report of Indiana for 1873, we find the statement that the black slate has been tried for manufacturing a roofing material by Dr. Samuel Reid & Co., but it could not withstand exposure to the weather. I also have seen it used for making fences on farms with the same unsatisfactory result. Small huts built from it exhibited a pile of crumbled pieces after a few years.

The reasons are already explained. Experiments have also been made in utilizing this slate as fuel. Fishermen on the Ohio River banks often use it in their camping fires together with driftwood. They know very well that freshly broken slates burn with a bright flame as long as the bitumen lasts. Slates exposed for some time to the atmosphere lose a great percentage of the bitumen. Experiments made with freshly pulverized slate blown with a blast into a furnace have rendered good results, but at the low prices of Indiana coal it would hardly pay to crush and pulverize slates for fuel.

Mr. Very, of New Albany, told me that fishermen near Blackiston's mill, on Silver Creek, set the slates on fire several years ago and that the fire burned for several weeks and could not be extinguished until high water overflowed it.

I also mention the fact that the natural gas used near Brandenburg, Ky., is all derived from the same slates. The bore hole made at Salem gave, at the depth of 1,775 feet, gas and petroleum for some months. When the writer visited Salem in 1894 it furnished gas for a few cooking stoves only.

One can not expect to find gas or petroleum in large quantities near New Albany in this stratum, as the slates are exposed and the inclination is so considerable that it would escape, there being no impervious roofing over it. When going along the roof of the slates, which at the foot of the knobs consist of three feet of hard, non-porous limestone, one can smell, especially on a still day, the penetrating odor of sulphurized carburetted hydrogen. The volatile components of the bitumens are escaping into the air and can not be utilized.

NEW WAYS OF UTILIZING THE SLATE.

During the fall of 1894 I made experiments in utilizing slate by dry, destructive distillation. It was my aim to produce directly from the slate an illuminating gas, but after long experimenting I finally came to the conclusion that it would be much better to distill at a very low temperature to get all the oil undecomposed. The resulting oil can be put to different uses, as gas-making, lubricating, burning, etc.

A retort made from four-inch pipe, six inches long, capped on both sides, was connected by three-quarter-inch pipe with a washing and refining apparatus. The retort filled with slate was subjected to red heat and the resulting gas collected in a tin reservoir. With this arrangement I obtained from—

5 lbs. of Pittsburgh coal	105 gallons of gas.
8.5 lbs. of black slate	45 gallons of gas.
8.5 lbs. of black slate, Ohio banks	50 gallons of gas.
8.5 lbs. of black slate, Falling Run banks	65 gallons of gas.
15 lbs. of freshly broken slate	105 gallons of gas.
15 lbs. of the same after exposure to air for 14 days	100 gallons of gas.

The gas was left standing for several days in the reservoir during cold weather without undergoing any condensation. It burned with a light flame which resembled petroleum gas light.

The Gas Light and Coke Company of New Albany made a trial last year to carbonize the slate, which is exposed a few hundred feet from their gas plant. Superintendent T. W. Dunbar, in a letter, says as follows: "I carbonized three tons of the New Albany black slate and obtained a yield of 2.20 cubic feet per pound of twenty-two candle power gas. Ordinary unenriched coal gas is about eighteen candle power. The quality of gas, therefore, is better and the yield 45 per cent. of that obtained from Pittsburgh coal. Of the amount of oil or tar obtained I know nothing, as I did not make any measurements. The slate does not materially change its color or form by being carbonized. The residue contains much sulphur, and, so far as I know, is useless for fuel. I made no scientific test. With the arrangement we have for making gas, it would not pay us to use the slate even though we could obtain it for nothing. The slate was obtained from near the exposed surface of a creek bottom, and I am sure that if a sample was gotten at a greater depth that a much better yield of gas would be obtained."

These are the results with a new raw material, "the Black Slate," worked in a gas plant having the apparatus suitable for Pittsburgh coal. As I have already mentioned, I discarded this process. It requires too much fuel to bring all the bulk of slates to the temperature necessary to convert all the bitumen into gas.

By selecting retorts which insure a quick movement of vapors into the condenser, it is possible to get at a very low temperature a great percentage of oil without much fuel expense. Crude oil obtained by atmospheric pressure from the slate exhibits a black coloration, has a very bad smell and is very difficult to refine. In oil obtained with stills provided with a vacuum pump the vapors are removed from the hot still walls as quickly as formed. At the same time the temperature necessary to form the vapors is materially lowered (about 100° C.). A vacuum of fifteen inches gave very good results. The oil is nearly colorless and without much smell. By leading into the still a small amount of steam and the vacuum apparatus left as in the last case, then in the watery part of the distillate ammonia was increased materially and can be used for manufacturing sulphate of ammonia.

It is well known that in a still of large dimensions the vapors are more easily overheated than in a laboratory still. Nevertheless the results of the experiments will be also true in working on a manufacturing scale. Taking into consideration its thickness of more than 100 feet, the State of Indiana possesses in this Devonian slate a storehouse of power greater than the coal seams, which can furnish an almost inexhaustible supply of oils for illuminating, heating and other purposes, provided the proper methods of utilization are devised. It is, therefore, of the greatest interest to learn as much as possible of the methods and apparatus used by other nations for working with profit a similar raw material.

It is surprising that in spite of the low prices of American and Russian petroleum it was possible in two different districts of Europe to carry on the manufacture of distilling with profit bituminous schists on an enormous scale. I mean the Scottish mineral oil industry with a yearly output of 60,500,000 gallons crude oil in seventy factories,[*] and the Actiengesellschaft A. Riebeckache Montanwerke, centering in the province of Saxony, with a yearly production of 17,348,650 gallons of crude oil. To-day the Scottish industry has adopted the Young and Beilby's retorts, and also the Henderson retort. At the close of the year 1890 there were 1,520 Henderson retorts and 3,528 Young and Beilby's stills in active operation, while 64,560,000 gallons of crude oil and 25,000 tons of sulphate of ammonia were produced. The crude oil yielded, after refining, the following products:

Naphtha	2,030,128 gallons.
Burning oil	19,086,650 gallons.
Gas oil—sp. gr. .840—.850	973,768 gallons.
Medium oil—sp. gr. .865	2,729,928 gallons.
Heavy lub. oil—sp. gr. .875—.95	6,440,632 gallons.
Soft scale paraffine	3,605 tons.
Hard scale paraffine	17,482 tons.

Young and Beilby's latest patented retort insures a greater gain of ammonia, and is, therefore, superior. After complete distillation of the volatile matters the shale is submitted to the action of steam under high pressure. The oxygen of the steam combines with the fixed carbon. The nascent hydrogen combines with the remaining nitrogen, forming ammonia. The good results obtained from this device have aided, to a great extent, to better the profit of distilling the schists. Mr. Fletcher's twenty-third Report on the Alkali Acts (26) states that in Ireland 18,080 tons of sulphate of ammonia were produced during the year 1886 from the shale works alone. The superiority as a fertilizer of sulphate of ammonia when free from thiocyanate is well known to the agriculturists.

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[*] Journal of Gas Lighting, 1894, I, p. 973; 1894, II, p. 605.

The refining of crude oil consists in repeated distillations and treatment with sulphuric acid and caustic soda. Before bringing the crude oil into the retort it is treated with a small percentage of concentrated sulphuric acid (66° Beaume) at 50° C. for some time. Air is blown into the mixing tanks. Sulphurous acid is evolved and resinous bodies are partly dissolved and partly precipitated as tarry matters; a continuous washing with water follows; finally the last traces of sulphuric acid are removed by baryta water. The crude oil is now ready for distillation. This is separated into fluid crude oil and the paraffine mass by subjecting the whole to a low temperature. Hard paraffine is pressed off in hydraulic presses, refined by bleaching with bone-char, and filtering through a filter press. The residue in the still is worked down to coke.

The Scots proceed in a somewhat different way. A first distillation separates the naphtha only. The rest of the distillate forms the "once-run oil." After the sulphuric acid treatment and precipitation of tarry matters, consisting of pyridin and pyroll bases, the oil is allowed to settle over night and the clarified portion is run into the soda washer and treated with caustic soda of 1.3 sp. gr. Cryselic and phenilic bodies are absorbed by the lye. The oil is now ready for the still, and is separated by fractional distillation into light and heavy oil. The sulphuric acid used for refining is generally utilized by boiling it with water and separating the precipitated tar. The resultant weak acid solution is sufficient to convert all ammoniacal compounds into the sulphate of ammonia. The soda tar is treated with carbonic acid, and the soda combines with it, forming carbonate of sodium, and the liberated creosote oil is obtained, which is well known for preserving timber. Of course the process is subject to changes, depending on the nature of the oils and their market price.

The Saxon Thuringia mineral oil industry is using the retorts invented by Rolle, 1858, with improvements made by Schliephake, Grotowsky and others. Their aim has been to produce an illuminating oil (Solar oil), but when American petroleum entered the European market a high percentage of hard paraffine became the desideratum. The "cracking" in the still was overcome by the use of "Körting's Dampfstrahlgebläse," an ingenious steam injector which furnished steam and at the same time created the partial vacuum.

The Scottish mineral oil trade has in the past had its hard times, but has so far always succeeded in finding new channels of utilization for its products. During the year 1890 the Scots put on the German market their overstock of crude oil. Wagner's Jahresberichte über die Leistungen der Chemischen Industrie, 1890, gives, on pages 83–89, a very interesting résumé by Oberkontz. On September 17, 1896, another very valuable addition to the uses to which the oil can be put was demonstrated to the Incorporated Institution of Gas Engineers.* The patented oil gas plant constructed by Mr. William Foulis at the Dawsholm gas works has already been found so satisfactory that a second apparatus is to be erected. The plant consists of three vessels—a generator for making producer's gas from coke, a retort for vaporizing the oil, and a retort for fixing the oil vapors in the form of gas. As spray, the oil is sent into the top of the retort against a plate or dispenser in such a way that it is broken up into a fine mist, which enables most of it to be gasified without coming into contact with the hot still walls of the retort.

The largest shale distilling works of the Scottish combination is the factory of Young, of Glasgow. It produced, in 1885, from 500,000 tons of shale, 72,000 tons of crude oil and 4,000 tons of ammonium sulphate. The crude oil yielded 6,000 tons of paraffine, 30,000 tons of burning oil, 4,000 tons of naphtha and 9,000 tons of lubricating oil.

†At Broxburn, shales have been worked since 1861. They contain about 20 per cent. of carbon, 3 per cent. of hydrogen, .7 per cent. of nitrogen and 1.5 per cent. of sulphur. In treating the shales with naphtha no other oil is obtained. The following are the products of distillation:

Crude oil	12 per cent.
Gas	7 per cent.
Ashes	67 per cent.
Ammonia water	8 per cent.
Carbon residue	9 per cent.

To get the best results by distilling, the temperature ought to be at a dark red heat. An addition of lime or soda during the distilling process has no effect. One ton of shale results, on an average, in 135 liters of dark green crude oil, 295 liters of ammonia water and fifty-seven cubic meters of gas, the latter being used for fuel and illuminating purposes at the works.

SOURCE OF BITUMEN.

In attempting to explain the remains of organisms preserved in rocks, we must constantly refer to animals and plants of the present age. By carefully comparing, and at the same time observing, all the surroundings of the place where fossils are found we are able to make conclusions which will give us a picture of the past ages.

Taking it for granted that the Genesee slates are a marine deposit, then we can certainly expect to find the remains of organisms of the Devonian sea preserved in the mud. It is remarkable that not a single shell has been found around New Albany in the slate formation. Let us now consider the possibilities under which marine plants are, perhaps, preserved.

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*Oil Trade Review, 1896, October.

†Stuart Town Soc. Chem. Industry, 1889, page 100.

Seaweeds are thrown on the sea shore by flood and storm and exposed to the oxidizing influence of air. The harder, more leathery kinds, as fuci, laminarias, etc., are able to withstand the weather for some time. The seaweeds are bleached by the exposure to light and begin to swell up by the absorption of moisture. By diffusion of this moisture through the membranes, the plants change slowly into a jelly-like substance; "the algin" and the salts are soon leached out. The more tender kinds are not able to resist any length of time and become disintegrated. They are completely changed into a sticky fluid which is absorbed by the sand. Very different are the conditions under which seaplants may be preserved on the bottom of the sea. Plants loosened by the waves of a storm sink by their higher specific gravity to the sea bottom and into the deposited mud, which forms a complete casing for the buried plant, excluding the decomposing influence of air, or at least reducing it to a minimum. Under such conditions it is very likely that a plant is preserved by carbonization. The products of the slow decomposition have saturated the surrounding mud and are represented by the bitumen (solid, fluid and gaseous) and the fixed carbon.

The Fifteenth Indiana Report on Geology, page 17, gives the following statement: "Vegetable remains consisting of huge tree trunks are found imbedded in the New Albany black slate, usually near the upper surface of the formation. These furnish, to my mind, a suggestion of the source whence has been drawn all the combustible matter dispersed throughout the slate."

Mr. Maurice Thompson thought that the small layer of three to four feet of driftwood imbedded in the blue clay on top of the New Albany black slate was sufficient to explain the source of an amount of at least 23 per cent. of carbonaceous matters in a formation of 104 feet thickness. Specimens of well preserved cones of conifers and nuts of walnut trees, found by myself, are a sure proof that it is really driftwood of a recent age, and not vegetation of the old Devonian formation.

I am also well aware of the paper written by T. F. James, custodian of the Cincinnati Society of Natural History on the "Fucoids of the Cincinnati Group." (Vol. 7, 1884–'85, Journ. Cincinnati Soc. Nat. History.) He comes to the following conclusion: Reviewing all the supposed algæ, there is not a single one which seems entitled to remain in the class. They are referred to three different sources: (1) To inorganic causes; (2) to trails and burrows of marine mollusks; (3) to hydrozoas.

The fossil plants which I describe below all show a carbonaceous film, and No. 1 is so completely preserved that every cellwall can still be seen. They all have been found in a very small district along the Ohio River, beginning near Force's handle factory and extending to the mouth of Falling Run. The banks are terrassic and accessible only at very low water.

DESCRIPTION OF DISCOVERED PLANTS.

Before my discovery of plants in the New Albany black slate no fossils had been found therein. I had only heard of some micro-organisms, but had never seen specimens of them. Writers in several of the past Indiana Geological Reports had expressed the wish that more information was available concerning the fossils of the black slate.*

Prof. David White of the United States Geological Survey has aided me much by giving me a list of American literature on Devonian plants. His own opinion about Nos. 1 and 4 is that they are "unique. I do not recollect anything like them." The plates, as well as the descriptions, will give a fair idea of the plants. I would also like to call attention to the fact that the plants are perhaps compressed and their original size is therefore somewhat changed. The plants are always found lying between the laminæ. I never found specimens perpendicular to the cleavage.

PARENCHYMOPHYCUS gen. nov.

(*Parenchymus*, cell. *Phycos*, seaweed.)

Fucoidal plants with parenchymatic cells and a flat, linear nodose thallus. The genus is based on *P. asphalticum*.

1. *Parenchymophycus asphalticum*, sp. nov. Plant with a band-like thallus from 10 to 150 mm. wide, the well preserved spongy parenchymatic cells always filled with asphaltum. The cell walls are rich in silica. Cross divisions (nodes) at regular distances divide the band into rectangular oblong pieces (internodes). The termination of the plant consists of an oval shaped bud similar to that of *Fucus vesiculosus* L. of the present age. The length of specimens found varied from a few centimeters to 183 centimeters. The cell walls of this most interesting sea plant have resisted so well the influence of decomposition that they served as a means of diffusion for fluid bitumen, which, after a long time, gave off the volatile components and left only the hard asphaltum. All specimens found show no ramification. (Pl. II., fig. 1.)

Locality: Ohio River banks at extreme low water between the handle factory of Mr. Force and the mouth of Falling-run Creek. I also found one specimen in the Silver Creek bed near Blackiston's mill. Specimens deposited at New Albany Society of Natural History in the fall of 1894, and at the State Museum, December, 1895.

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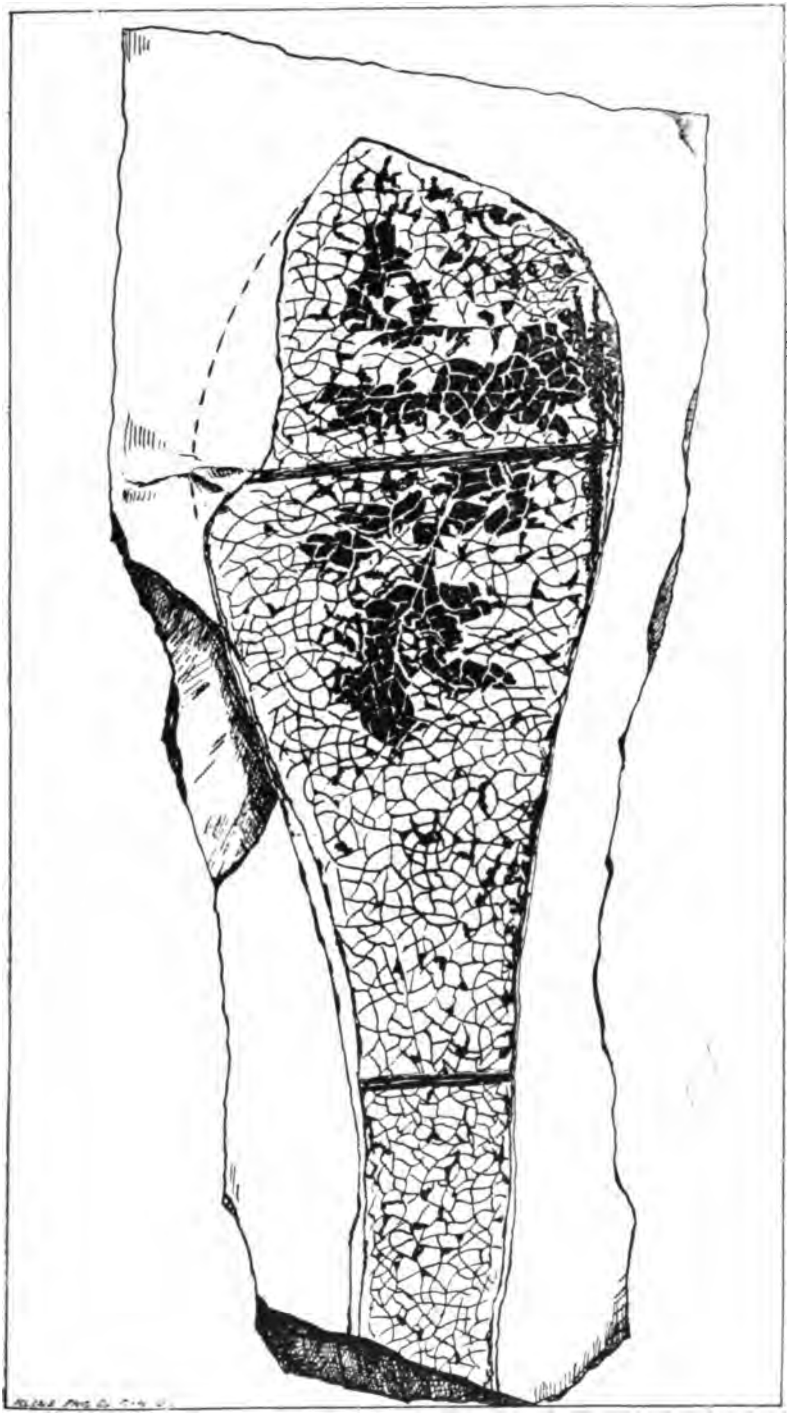
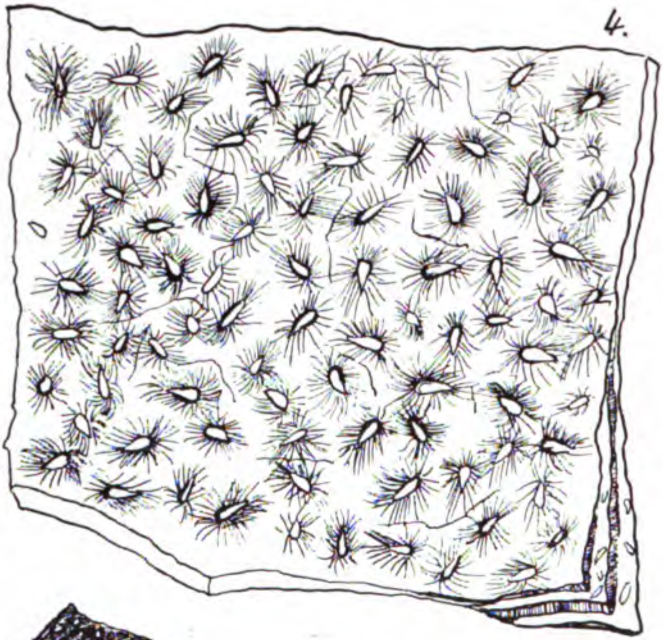
*1873, page 158; 1885-86, pages 16-17; 1888, pages 60-61, 198.

PLATE II.

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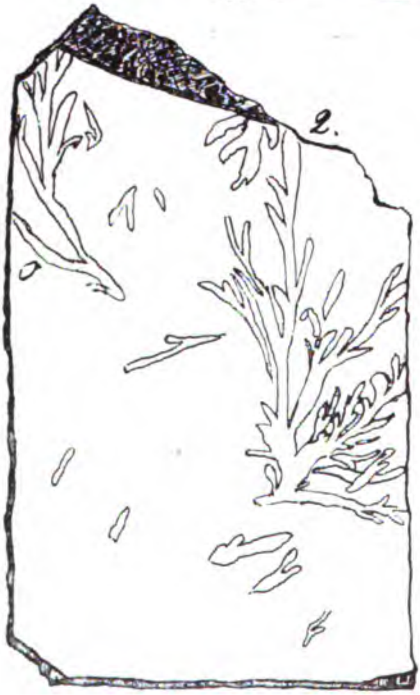
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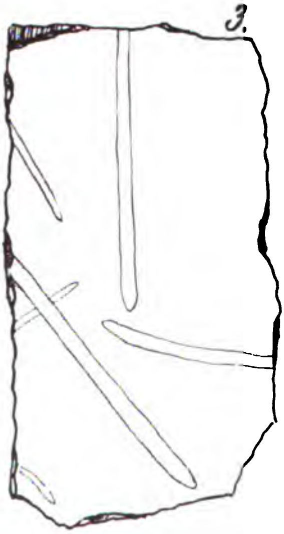

3.

PALAEOPHYCUS Hall.

(*Palaios*, ancient. *Phycos*, seaweed.)

Stems simple or dichotomous, branches cylindrical or slightly flattened with the obtuse surface smooth or dotted. Type *Palaeophycus tubulare*, Hall, 1847, Pal. N. Y., Vol. I, p. 7.

2. *Palaeophycus new-albanense* sp. nov. Thallus flat, linear, entire, often branched; ramification, dichotom branches erect alternate, branchlets leaflike, tapering gradually into a narrow, more or less prolonged termination. Thallus 1 to 2½ millimeters wide. Length of plant from 6 to 10 centimeters. (Pl. III., fig. 2.)

Locality: Ohio River banks at New Albany.

3. *Palaeophycus lineare* sp. nov. Thallus flat, linear, entire, very rarely branched, 2 to 4 millimeters wide and sometimes of considerable length. Similar to *Corda fillum* of our seas. (Pl. III., fig. 3.)

Locality: Ohio River banks at New Albany.

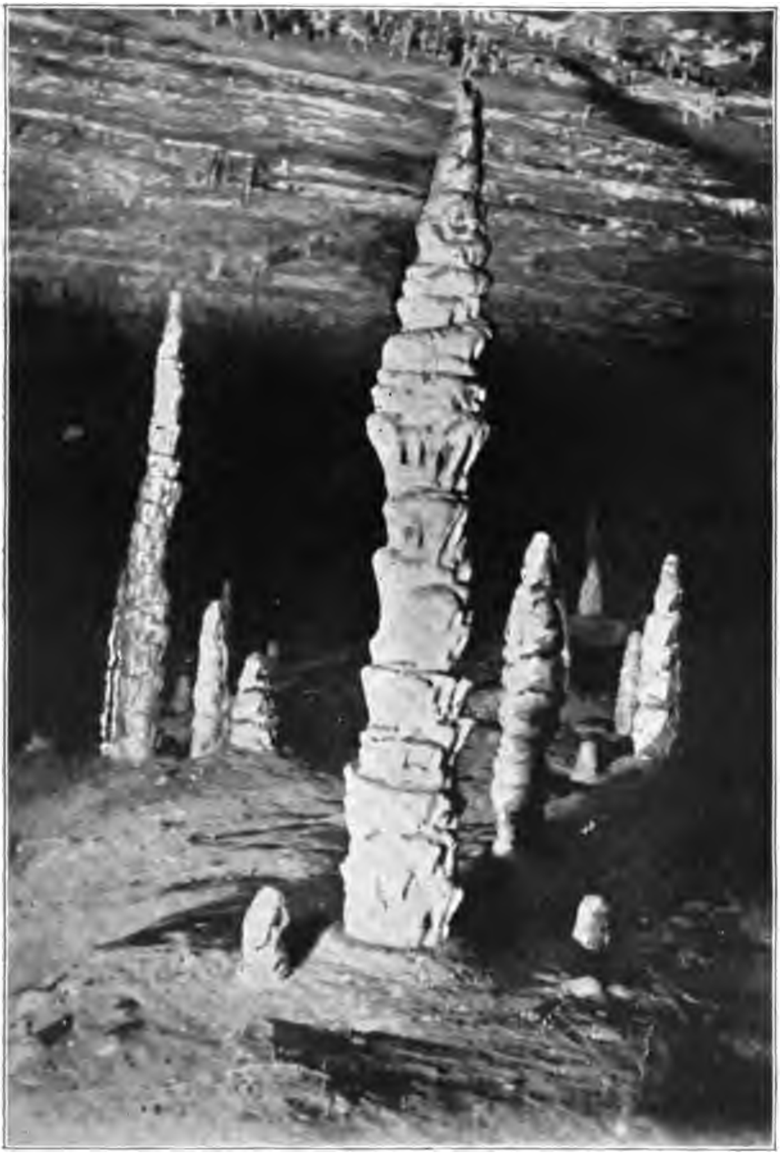
SPORANGITES Dawson.

(Seed Vessel.)

Dawson, 1863, Can. Nat. and Geol. Vol. 8. Type *S. gapillatus*, Dawson.

4. *Sporangites radiatus* sp. nov. Ovoid shaped bodies with radial hairs around them. Completely filling the slates at some places. I have only found specimens of this organism near specimens of *Parenchymophycus asphalticum*, and this fact caused me to believe that they are perhaps spores of this gigantic fucoid. (Pl. III., fig. 4.)

Locality: Ohio River banks.



WASHINGTON'S MONUMENT MARENGO CAVE.

INDIANA CAVES AND THEIR FAUNA.

BY W. S. BLATCHLEY.

The subcarboniferous limestone area of southern Indiana contains many sink holes and caves within its bounds. This area is, for the most part, embraced in the counties of Owen, Monroe, Lawrence, Washington, Orange, Harrison and Crawford. Going southward from the center of the State, the sink holes first become a prominent feature of the surface in eastern Owen and western Morgan Counties, and are found in numbers thereafter, in the area mentioned, until the Ohio River is reached, beyond which, in Kentucky, they are said to be still more numerous, in many portions of the State averaging 100 to the square mile. These sink holes vary much in size, sometimes being but a rod or two across, and again embracing several acres in extent. They are, for the most part, inverted cones or funnel shaped cavities, and, where small, usually have the sides covered with a matted growth of vines and shrubs. Where larger, trees of varying size are often found growing from the scanty soil on the sides, or from the bottom of the sink. If one will examine closely the lowest point of a sink hole, he will usually find a crevice or fissure through the limestone, or sometimes a large opening which, if it be possible to enter, will be found to lead to an underground cavity—a cave.

Sink Holes.

Both sink holes and caves not only owe their origin, but usually their entire formation, to the slow, unceasing action of rain or carbonated water upon the limestone strata in which they occur.

Carbon dioxide (CO_2) is present everywhere in the atmosphere, constituting about three parts in 10,000 of the volume thereof. The condensed vapors, falling as rain, unite with a portion of this carbon dioxide, and form a weak carbonic acid or rainwater ($H_2O + CO_2 = H_2CO_3$). This acidulated water, wherever it comes in contact with limestone, brings about a chemical change, calcium bicarbonate, $CaH_2(CO_3)_2$, being formed. By this change the limestone is dissolved and carried onward with the seeping or flowing waters. The action of the rainwater upon the limestone is usually hastened by humic acid, with which the former has combined in passing through decaying vegetable matter before reaching the limestone.

Formation of Sink Holes and Caves.

In the beginning of a sink hole, the rainwater seeps through a crevice or joint of the limestone to a lower stratum, along the surface of which it finds a passage. By gradually dissolving the stone, this passage-way becomes increased, until finally a large cavity is formed immediately below the surface. The unsupported weight of the latter causes it to gradually sink downward and assume the inverted cone shape above mentioned. The opening at the bottom becomes larger, allows more water to enter, and a more rapid dissolving takes place between the layers. As soon as the underground passage has become large enough to allow a good-sized stream to enter, the process of erosion or abrasion is added to that of the solvent action of the water, and the enlargement of the passage goes on much more rapidly. This gradual enlargement continues for hundreds, perhaps thousands, of years, and results in a cave, varying in size according to its age, amount of water flowing through it and the softness of the rock dissolved or eroded. The larger caves possess great vaulted rooms, deep pits, high water-falls and streams of water, some of the latter large enough to allow the ready passage of a good-sized boat.

From the above it will be seen that sink holes and caves are closely related, the latter, in fact, being largely dependent upon the funnel shape of the former to collect the surface waters and direct the flow thereof. A number of sink holes often connect by narrow and tortuous channels with the same underground passage, the latter increasing in size with the addition of each new branch, until finally it attains majestic dimensions.

Formation of Stalactites and Stalagmites.

The rooms and passages of limestone caverns are often, subsequent to their formation, partially filled by those handsome forms of crystalline limestone, called stalactites and stalagmites. These are seldom, if ever, formed in great numbers, except where the passages or rooms are relatively close to the surface. The water, charged with carbonic acid, filters slowly through the soil, and, entering the narrow crevices and joints between the layers of stone, seeps downward until it reaches the roof of an underground cavity. Here the slowly dripping water comes in contact with the air of the cave. The liquid is evaporated and the solid particles of carbonate of lime, dissolved from the rocks with which it had come in contact, are left behind. Each successive drop thus deposits or leaves a solid particle until finally a pendent cylindrical mass, called a *stalactite*, and resembling in general form an icicle, remains suspended from the roof.

Where the water thus dripping through the roof of a cavern is greater in quantity than can evaporate before it falls, it drops from the stalactite to the floor below. There it splashes outward and in time evaporates, leaving the solid particles brought down. These accumulate one on top of another until finally a cylindrical or cone shaped mass protrudes upward, slowly growing in size, each successive layer being distinct from the preceding. This upward rising mass is a *stalagmite*. It is almost always greater in diameter than the stalactite above it. Often the two in time meet, and a column or *stalacto stalagmite* of crystalline limestone results. Down the sides of this the incoming waters slowly flow instead of drop, evaporating and leaving their solid particles as they move, thus increasing in size the diameter of the column. If this action continues long enough, the whole passage or room may be filled by these deposits and all semblance of a cave obliterated. It will thus be seen that water, where it flows freely and rapidly through massive beds of limestone, dissolves and erodes great cavities therein; where it seeps and oozes through such beds, it tends to fill up the cavities already formed. Where the slow flowing water has passed through large masses of pure crystalline limestone, the resulting stalactites and stalagmites are often very clear, almost translucent. Where sediment and mud is carried down with the carbonate of lime, the resulting formations assume a dirty brown and unattractive appearance.

The following figure, with its accompanying explanation, will probably aid in making clear the above statements concerning the formation of limestone caverns:

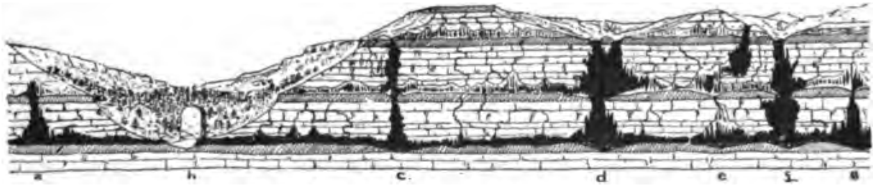


FIGURE ILLUSTRATING THE FORMATION OF CAVES IN LIMESTONE.

S, sink-holes; a, c. d, f, g, rooms in cavern; b, natural bridge formed by the sinking of the roof of a former very large room; e, passages showing numerous stalactites. (After Shaler.)

Many small caves, and doubtless some large ones, exist in southern Indiana whose presence is as yet unknown, In searching for them the bottom of a sink-hole will be the best starting point, the only thing necessary being to blast or dig out the cavity commonly found there, until it becomes large enough to allow a person to enter.

But little has heretofore been written about the caves of Indiana. A number of short descriptions of Wyandotte cave have appeared in the previous geological reports and in various newspapers and magazines; and several of the smaller caves have been briefly mentioned in the reports on the counties in which they occur. A bibliography of such papers will be found at the close of the present paper.

As the Indiana caves are mostly found in the upper strata of the oölitic limestone area, the writer, in June, 1896, decided to visit the more important ones, with the object of making a careful investigation of their more salient features, securing their dimensions and collecting representatives of the forms of animal life which inhabit them, so that a report concerning them might be prepared and published in connection with an article on the oölitic limestone area, then in course of preparation by Messrs. Hopkins and Siebenthal.

Accordingly a party of five, consisting of Messrs. John B. Peddle,* John S. Michaels, F. H. Blatchley, O. F. Fidlar and the writer, started on the 4th of July with the necessary camp equipage, collecting apparatus, etc., in a two-horse spring wagon, for a five weeks' trip of cave explorations.

PORTER'S CAVE.

The first cave visited was in the northeastern corner of Owen County, on the farm of P. Applegate (east half of section 33, township 12 north, range 2 west). The mouth of Porter's Cave is very close to the line between Owen and Morgan Counties, and the source of the stream which flows therefrom is about one-half mile northeast in Morgan County. The cave is little more than a narrow, water worn passageway through the rocks, which at this point consist of St. Louis and Keokuk limestones, the former comprising the roof and the latter the floor. The portion cut out seems to be softer than either and approaches in appearance a dolomite or magnesian limestone.

The mouth of this cave is the most beautiful of any visited. It is in the side of a hill at the head of a narrow canyon, or gulch, which has been eroded by the stream which flows from the cave. From the floor of the cave to the bottom of this gulch the distance is 33 feet, down which the stream flows in a perpendicular waterfall. The mouth of the cave is 50 feet wide and 14½ feet high, the roof extending out in a broadly arched front several feet beyond the face of the waterfall below. The rock down which the water flows is covered with moss, and in the early morn, when the sunbeams light up the interior of the cave for a distance of 75 or more feet, and glisten and sparkle from the mossy background of the falling water, the scene is a most entrancing one.

The cave can be entered only by a narrow footpath on the northern side of the mouth. Twenty feet back from the entrance the roof becomes flat, and for almost 100 feet is comparatively smooth, being composed, apparently, of one immense slab of St. Louis limestone. In this distance the width gradually narrows to 30 feet. The floor is wholly of rock, in some places covered to a depth of several inches with sediment and loose stones brought down by the running stream. The latter for the first 270 feet is from four to eight feet wide and two to five inches deep. It meanders from side to side of the floor, making the frequent crossing of it a necessity. Beyond 270 feet it covers the entire floor to a depth of from six to twenty inches, and farther explorations must be made while wading.

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*Mr. Peddle at present occupies the chair of drawing in the Rose Polytechnic Institute at Terre Haute, and to him the credit for the photographs and maps of the caves, with the exception of those pertaining to Wyandotte, belongs.

The roof after the first 100 feet varies much in character, sometimes being regularly arched with a height of but eight to ten feet; and again very irregular, the sides gradually merging 25 to 30 feet above the floor.

But few stalactites occur in the cave and they are dirty brown in color. At a point 250 feet from the entrance a very large one partially shuts off the passage way, and 645 feet in, a similar one which has had its lower portion broken off, is found. At 750 feet the roof becomes so low that one has to stoop, and the width is reduced to 18 feet. From this point onward both height and width gradually diminish until at 852 feet it became necessary to crawl through water, and further exploration was abandoned. It is claimed that in a dry season persons have passed entirely through the passage, crawling for several hundred feet and then emerging into a low room near the source. A visit to the latter showed that it was not a true sink hole, but a passage-way worn through the rocks in the side of a low hill. The opening was ten feet wide and about four feet high and a short distance back expanded to twenty-five feet in width, but soon narrowed again to eight feet, and 150 feet from the entrance the roof came down close to the water and stopped farther progress. Except to the naturalist there is little attraction about Porter's Cave other than its mouth; but that alone is well worthy a visit by all who enjoy the picturesque and beautiful in nature.

FAUNA. No vertebrates were taken or noted in Porter's Cave except the cave salamander *Spelerpes maculicauda* (Cope), several specimens of which were secured within 200 feet of the entrance. They were clinging to the damp walls of the cave and showed little fear when approached. The raccoon, *Procyon lotor* (L.) visits the cave in numbers and evidently passes entirely through it, as was evinced by the tracks, which were very plentiful along the margins of the stream. To their visitation is probably due the absence of crayfish and other crustaceans, no specimens of which were secured.

Among insects, out-of-door forms were quite numerous, having been drifted in by the flowing water, or else having voluntarily sought shelter within the cave. All the coleoptera or beetles taken were of these above-ground forms, and consisted of six specimens of *Platynus cincticollis* Say, taken from beneath stones within 100 feet of the entrance; one specimen each of *Bradycellus rupestris* Say, *Stenolophus ochropezus* Say, and *Cryptobium bicolor* Grav., each between 50 and 150 feet back, and a single speciman of *Scarites substriatus* Hald., crawling over the mud at 415 feet from the mouth.

Of Diptera a number of specimens were taken from seventy-five feet on back as far as exploration was made. They were found on the sides of the cave and were readily captured. They represented four species, three of which, belonging to the genus *Blepharoptera*, were afterward found in a number of other caves visited. Of the examples from Porter's cave *B. specus* (11 specimens) and *B. latens* (2 specimens) were new to science and their description will be found in the paper on Cave Diptera, by Mr. J. M. Aldrich, in the present report. The remaining species was *Ulomorpha pilosella* O. S., represented by a single specimen taken 750 feet from the mouth.

One Orthopteron, *Ceuthophilus stygius* Scudd., was captured 250 feet from the mouth, and several others, probably of the same species, escaped beneath some heavy stones. A caddice fly, *Trichoptera sp.*, was taken at 750 feet, and had probably hatched from the water flowing through the cave. Two specimens of *Conotyla bollmanii* (McNeill), a true cave myriapod, were taken from beneath stones within 150 feet of the entrance.

Three species of spiders were collected in this cave, as follows: *Nesticus carteri* Em., and *Tmeticus tridentatus* Em., both true cave forms, a single male of the former, 780 feet from the mouth and a pair of the latter at 240 feet; both species crawling over the floor. In the upper end of the cave a half dozen specimens of a small spider were taken which proved to be new to science, and is described by Mr. Nathan Banks in the supplement to this paper under the name of *Theridium porteri*. It was found on the walls or roof and near each specimen was often two and always one small globular cocoon, suspended by a single thread from the roof or a projection of the wall. Scattered threads of webs were also noted, but ran in no definite direction.

The only vegetable form noted in this cave was a fungus, which was branching and ramifying over the rocky wall at 750 feet from the mouth. The same or a similar species was found on some small pieces of driftwood a short distance further on.

SPRING CAVE

is located in Owen county, about one and a half miles southwest of Porter's Cave, in the (northwest quarter, section 5, township 11 north, range 2 west). A good sized stream flows from a large room, 40 feet wide, 12 feet high at the mouth, and almost 60 feet long; and plunges down a narrow chasm worn in the rock for 25 or 30 feet to the bottom of the ravine below. The single room mentioned was the only portion of the cavern large enough to explore, as the roof gradually lowers and at a distance of 82 feet from the mouth comes down within 18 inches of the top of the water. The only living creature found in the cave was a crawfish, *Cambarus bartonii* Fab., taken from the stream about 50 feet back from the mouth.

MAYFIELD'S CAVE.

This cave is but a long, narrow subterranean cavity, varying in width from 8 to 20 feet. The mouth of it is located 400 yards south of the center of Sec. 26 (Tp. 9 N., R. 2 W.), Richland Township, Monroe County. At the time of our visit the entrance was boarded up, and the first 50 feet was in use as a storage house for milk and vegetables.

But few side passages branch off from the main cave, and they are usually short and narrow. The average height of the main passage is 6 to 8 feet, and there are but few places where crawling is necessary. At 650 feet from the entrance a narrow passage leads down a descent of 8 to 10 feet, and here the first pool of water is found. Several other pools occur at intervals thereafter, but no running stream was present. At a distance of 1,475 feet from the entrance the main passage terminates in a circular room 22 feet in diameter and 7 feet from floor to ceiling. From this room a narrow "corkscrew" passage 288 feet long, 2 feet 8 inches wide and 2½ feet high, runs in a general southwesterly direction. Twenty-nine sharp turns are made in this distance, when it becomes too small for further progress. This passage has been eroded through a stratum of soft shale. The main passage of the cave appears to have been originally filled with a hard, indurated clay, on top of which rests a stratum of oölitic limestone.

Fauna. No vertebrates were found in Mayfield's Cave. In the pools occurred three species of crustaceans; namely, the blind crayfish, *Cambarus pellucidus* (Tellkam.), a small, shrimp-like form, *Crangonyx gracilis* Smith, and a still smaller species, *Caecidotœa stygia* Packard. But one or two specimens of each were taken. These forms had previously been found in this cave by the late C. H. Bollman, of Bloomington.*

Among insects a small Thysanuran, *Degeeria cavernarum* Packard, was most common, being excessively abundant in damp places on the floor, and especially beneath flat stones in the vicinity of any decaying matter. Several specimens of the true cave myriapod, *Conotyla bollmanii* (McNeill), were taken 275 feet from the mouth, while a single specimen of an above-ground form, *Spirostrephon lactarium* (Say), was found on the roof 506 feet from the entrance.

Of beetles, two true cave forms were here found. A single specimen of a carabid, *Anophthalmus tenuis* Horn, was found crawling rapidly over the side of the "corkscrew" passage, and two specimens of the common cave Staphylinid, *Quedius spelæus* Horn, were secured from beneath a decaying lemon skin, left by some former visitor.

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* Packard, "Cave Fauna of N. A.," 1889, 16.

The cave flies, *Blepharoptera latens* and *B. specus*, were frequent on the walls, ceiling, or on flat rocks on the floor. Two or three of the young of the most common spider found in Indiana caves, *Meta menardi* Latr., were also taken. But one half day was spent in the cave, and additional forms doubtless pass their lives therein. Mr. Bollman, according to Packard, *loc. cit.*, found a species of *Machilis* a few rods within the entrance.

TRUETT'S CAVE.

The source or opening of this cave is in a sink hole on a hillside in the southeast quarter of section 4 (township 8 north, range 2 west), about five miles west of Bloomington, Monroe County. The mouth of the stream which has formed it is, as yet, unknown. The opening leading into the cave is very small, and descends rather abruptly for about twenty-five feet. It then expands into a room about sixty feet in diameter, with a roof eight feet high. This room contains many large masses of fallen rock, which occupy much of the space and cause it to appear smaller than it really is. Stalactites are plentiful, but are mostly fragmentary, having been broken by many visitors, the cave being a favorite resort for students from the State University, who wish to get a glimpse of underground life.

At the farther end of this first room the floor descends, and a narrow passway is found leading into a second smaller room. From this another narrow descending passway leads to the main passage of the cave, 280 feet from the entrance. This passageway leads both to the right and left. Taking first the former branch, which is about fifteen feet wide and six feet high, we follow it, stooping at times where the roof comes down to four feet or less, for about 500 feet, where, after ascending a narrow, rugged pass, we find ourselves in the largest room of the cave, 115 feet in length, fifty feet wide, and with an average height of twelve feet. Like the room first entered, this is largely filled with great masses of fallen limestone. In one place these masses extend nearly to the ceiling, and almost separate the room into two compartments. By climbing down the rocks to the lower edge, we find the muddy bed of a stream; but the opening of the passageway leading outward has been choked up, and farther progress is barred. Explorations have in the past been made for two or three hundred feet through this passage, but it is for the most part very narrow and over much of the distance it is necessary to crawl.

Returning to the forks of the main passageway, 280 feet from the mouth, the left branch is entered. For a distance of 150 feet it is six to nine feet high and about twenty feet wide. It then narrows to six feet and the roof comes down to four, until finally, crawling upward through a crevice between fallen rock, we enter a room about twelve feet high, 140 feet long and fifty feet wide, which is partially, in some places almost wholly, filled with fallen rock. The farther end of this room was 600 feet from the entrance, and as no opening large enough for passage leads onward from it, we retraced our steps, leaving the room by a pit-like hole fifteen feet deep, which opens into the main passage thirty feet back of the narrow crevice through which we had crawled into the room.

The only water found in Truett's Cave at the time of our visit, July 9, was in shallow, isolated pools in depressions in the lowest parts of the floor of the main passage. The cave seems to be more recent in its origin than many visited, though the stream which originally formed it has disappeared or sunk to lower levels for its passage way. It presents no scenes of interest, except those of the rugged masses of fallen rock in the main rooms.

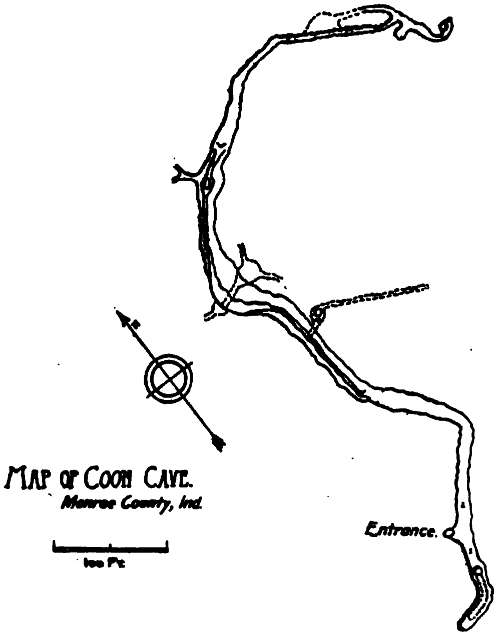
Fauna. No vertebrates were found in Truett's Cave, though signs of raccoons, mice and bats were plentiful. On account of the absence of water, crustacean life was wholly unrepresented. Of myriapods, the true cave form, *Conotyla bollmanii* (McNeill), was common beneath stones and pieces of wood, from 400 feet onward. The Thysanuran, *Degeeria cavernarum* Pack., was also abundant in damp places on the floor. The small spider, *Theridium porteri* Banks, was frequent about the walls and ceiling of the first room entered. One blind beetle, *Anophthalmus tenuis* Horn, and several specimens of the cave staphylinid, *Quedius spelæus* Horn, were found about the decaying remains of a feast in the left main passage, 500 feet from the entrance. Here, also, were found two specimens of an Aleocharinid beetle, which was not collected elsewhere on the trip.

Two species of Diptera were taken from Truett's Cave, namely, *Macrocera hirsuta* Loew, recorded heretofore only from the District of Columbia, and *Limosina tenebrarum*, a new species described by Prof. Aldrich in a supplemental paper to this report. These constituted the only animal forms collected, though, doubtless, protracted searching would disclose a number of other inhabitants of the cave.

COON'S CAVE.

The entrance into this cave is a perpendicular pit or well, forty-six feet deep and about six feet in diameter. The top of this pit is at the bottom of a rather shallow sink hole in the southwest quarter of section 8 (township 8 north, range 2 west), about seven miles west and two miles south of Bloomington, Monroe County, Ind.

The cave, like Truett's, Mayfield's and Blair's, is in the upper or blue stratum of the St. Louis limestone. This stratum underlies the Clinton sandstone and overlies the true oölitic stone of the St. Louis formation.



1. **Right-hand passage.**
2. **Left-hand passage.**
3. **Cleft in floor.**
4. **Lower passage.**
5. **Blue Pool.**

The descent into the cave was made by a rude ladder which had been constructed of poles by some previous explorer. At the bottom of the pit one finds himself on the edge of a passageway, about ten feet high and nine feet wide, which extends both to the right and the left. The right hand passage is but about ninety feet long, the roof and floor gradually converging and being but a foot or so apart at that distance. Thirty-five feet from the entrance is a hole in the floor of this right hand passage, through which one can be lowered by a rope fifteen feet to the floor of a lower passage, twenty-five feet long, ten feet high and six feet wide, which extends nearly parallel to the passage above. By the side of a smaller opening is a stalactite, seven feet, six inches long and five feet five inches in circumference, suspended from the bottom of the upper floor into the passageway beneath.

The left hand passage comprises the greater portion of the cave. It varies in height from four to twenty feet, averaging about eight. But little stooping or crawling is necessary, but much climbing over rough stones and up and down steep, rugged slopes has to be done, the floor in most places being covered with great masses of fallen rock. Two hundred and forty feet from the entrance a crevice leads off through the walls on the right. By crawling along a ledge of projecting stone for about 100 feet, we reach the edge of an opening large enough to admit the body of a man, and by aid of a sapling, bearing numerous short prongs or remains of limbs, which we found in place, we descended twenty-eight feet into a lower passage, about sixty feet long and ten feet wide. Here we found some shallow pools of water, but no living forms, and nothing in the way of scenery to reward us for the labor of getting down and up.

In numerous places the floor of the main passage has a deep cleft near its center or on one side, varying in depth from eight to twenty feet, and in width from a few inches to three feet and more. In several other places, notably 340 feet from the entrance, are openings or deep pit-holes, similar to those already mentioned leading down into lower passages, the latter, however, of small extent. The main passage begins to narrow about 575 feet from the entrance, and 100 feet farther on is but three feet in width. At this point a branch turns to the left and leads downward into a lower room of small size. A short distance beyond this branch the main cave ends in a small crescent-shaped room, in the farther end of which, 750 feet from the entrance, is a deep crevice in the floor, filled with the most limpid water that had ever been seen by any member of the party. This pool of water was four feet wide and appeared but three or four feet deep, but actual measurement showed it to be nine feet, three inches in depth. The length of the pool could not be determined, but it extended down a branch passage to the right, covering all the floor thereof as far as one could see. For two or three feet above the water-line the walls of this room are covered with small but most beautiful crystals of calcite, which reflected the light of our candles in a most brilliant manner. Numerous small stalactites of the clearest crystal stud the walls and project from the crevices of the roof, while the floor is largely composed of calcite, derived from the overflow and subsequent evaporation of the water from the pool. This room is, in truth, a fairy grotto, decked with jewels resplendent, and a view of it will well repay for all the time and toil necessary to step within its bounds.

FAUNA. Bats were the only vertebrates found in Coon's Cave. Here and there a single individual hung head downward from the roof, but all were of the single common species, *Vespertilio subulatus* Say. In winter they must occupy the cave in large numbers, judging from the amount of their excrement noted within its confines. No crustaceans were found, and of myriapods but a few dead specimens of *Conotyla bollmanii* were noted.

A single specimen of an unknown beetle belonging to the family Silphidæ was taken from beneath a stone 150 feet from the entrance, while of the common cave staphylinid, *Quedius spelæus* Horn, three specimens were secured. The Thysanuran, found in most of the Indiana caves, was plentiful in damp spots on the floor. One species of fly, *Blepharoptera pubescens* Loew, represents the Diptera taken, though *B. latens* and possibly *B. specus* were seen. Of spiders, two species, *Nesticus carteri* Em.

and *Meta menardi* Latr., were the only ones found, and complete the list of animals noted within the cave.

STRONG'S CAVE.

The entrance to Strong's Cave is situated near the center of the northeast quarter of section 34, Richland Township, Monroe County, and about three-quarters of a mile northwest of the Cross Roads church, which is four miles west of Bloomington. The mouth of the cave is about 200 yards west of two sink holes, which carry off the surface water of perhaps one square mile of territory. This water in time finds its way through the lower levels of Strong's cave to Strong's spring, one-half mile west.

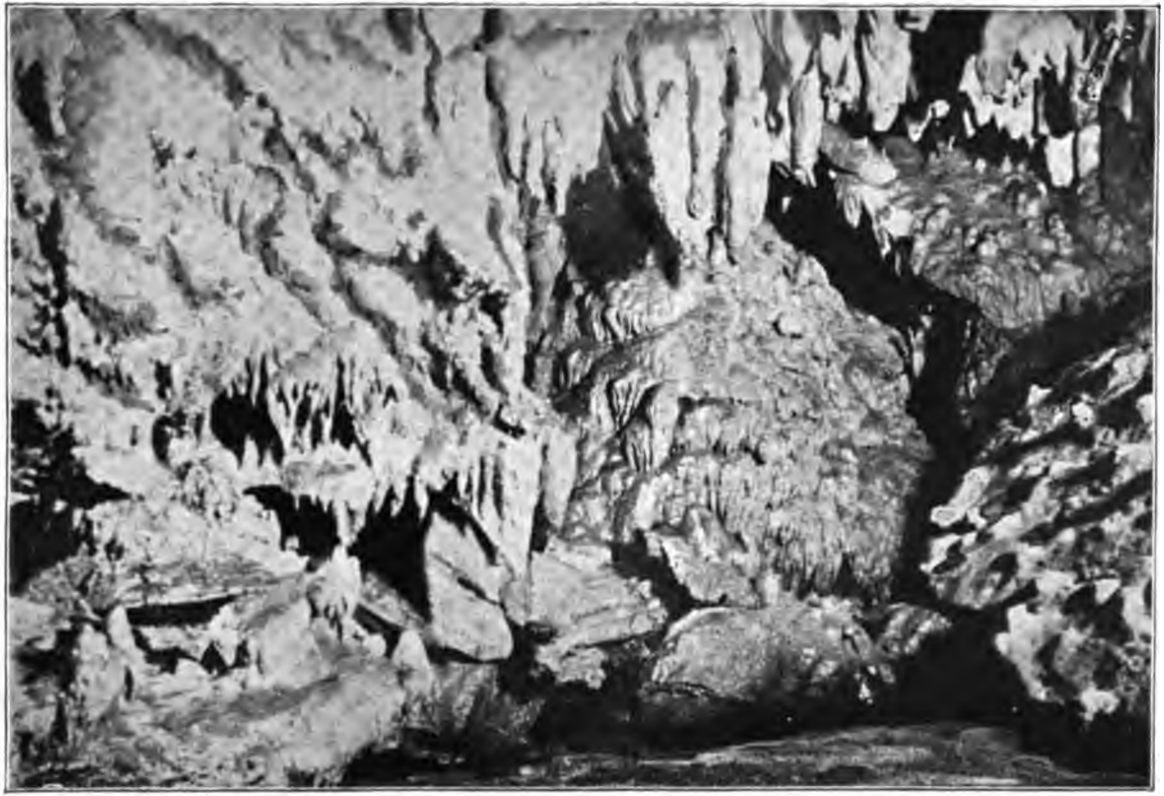
The entrance to the cave has the external aspect of a sinkhole. Descending into this one finds himself in a small room, with a passage leading on in the general direction of the cave, and another one at right angles leading downward a distance of about 20 feet to running water. The water comes from the direction of the sinkholes referred to above, and goes by a lower, impassable channel in the general direction of the cave.

From the room near the entrance, after crawling along a low, flat passage for 70 feet and decending a declivity, one enters a large room 50 feet long, 15 feet high and from 15 to 25 feet in width. This room contains on the west side some handsome stalactites, and beneath can be heard the murmur of running water.

Beyond this room is the most interesting portion of the cave, a room 20 feet long, 20 feet high and 25 feet wide. The floor is quite inclined, so that the farther end reaches the water level and contains standing water. At the junction of this room with the one just described is a passage 14 inches in height, which opens upon a shelf in the side wall about five feet from the floor and leads off through a maze of pillars and stalactites. The feature of this room is the beautiful "Hanging Garden." This is upon the west wall of the room, and consists of such a wealth of pillars, columns, flutings, stalactites, stalagmites and botryoidal concretions as to require no great stretch of the imagination to see fruit, flowers and statuary.

From the room of the Hanging Garden one passes by stooping and crawling over mud, gravel and running water through a passage 10 to 12 feet wide and varying from 6 feet to 30 inches in height, with a flat roof covered with innumerable "needle" stalactites, of whose existence one is often made unpleasantly conscious, for a distance of 257 feet to the Star Chamber.

This room is 60 feet in length, 8 feet in height, with a flat roof, 15 feet in width at the near end and 28½ feet at the farther end, where it is cut



THE "HANGING GARDEN," STRONG'S CAVE, MONROE COUNTY, INDIANA.

squarely off by an even wall. The stream which runs along one side of the room finds its way beneath this wall and pursues its course to Strong's spring, a half mile distant. The smooth, square dingy walls of this room, the lack of cave detritus, the oppressive silence, all go to make the name Star Chamber an appropriate one. The grime upon the walls shows that this room, as well as the whole passage back to the lower part of the room of the Hanging Garden, is flushed with water during the rainy season.

Near the entrance to the Star Chamber is another passage that leads back toward the mouth. It is from six to twelve feet in width and from three to eight feet in height. It rises in the direction of the mouth of the cave, and after tortuous winding among pillars near the mouth opens out upon the shelf at the nearer end of the room of the Hanging Garden, thus making a complete circle underground. The cave in all as described above measures 667 feet in length.

FAUNA. Above-ground vertebrates visit Strong's cave in numbers, as evinced by their tracks. A raccoon or mink, in his subterranean prowlings through the low, wet passageway beyond the Hanging Garden, was disturbed by us and a great splashing of water resulted. No blind crawfish were found and but one seeing one, *Cambarus bartonii* Fab., which seems to have a liking for underground life, having been secured in a number of caves. One other crustacean, *Cæcidotæa stygia* Pack , was found in small numbers in the stream nearest the entrance.

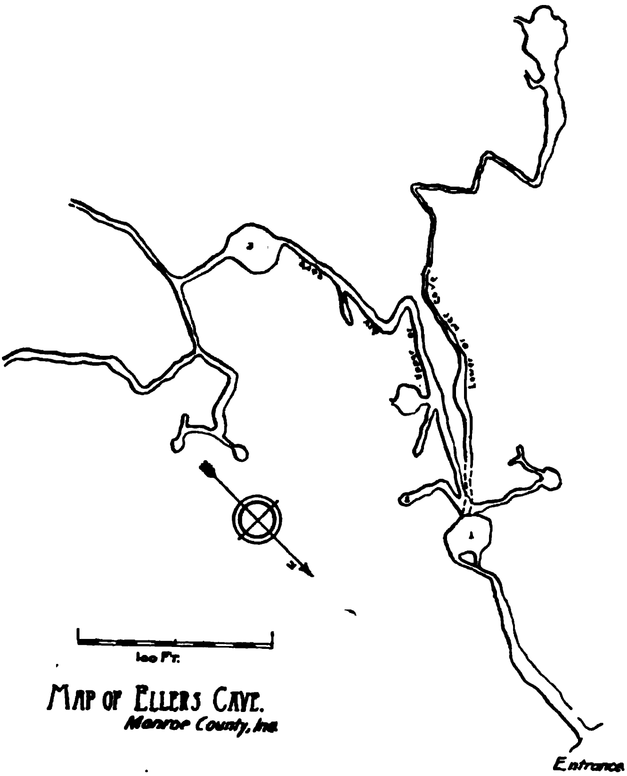
The cave cricket, *Ceuthophilus stygius* (Scudd.), was represented by several immature specimens taken from among the pillars and stalactites in the passageway leading back from the "Star Chamber." The cave spider, *Meta menardi* Latr., was common in the cave, the individuals varying much in age and size. No flies or myriapods were secured, though specimens of a form of *Blepharoptera* were noted.

ELLER'S CAVE.

The entrance of this cave is at the bottom of a sink hole, 100 feet in diameter, in the southwest quarter of section 15 (township 8 north, range 2 west), Monroe County. The cave itself is a double floored one, the upper and older floor being dry, and the more recent and lower floor having a stream of water flowing through the greater part of its length.

The entrance, about six feet wide and six and a half high, descends gradually for about fifty feet, and there expands into a room twenty feet wide, thirty feet long and twenty-five feet high, which serves as a vestibule or starting point for both floors, the entrance to the upper one being in the wall, about eight feet above the floor.

1. **Vestibule.**
2. **Bear-wallow.**
3. **Round-room.**



MAP OF ELLERS CAVE.
Monroe County, Ind.

Two passages lead from this vestibule into the lower floor, one to the right through a narrow winding cleft in the rock, and then down to the bed of a stream, along which, by crawling, we advance, until we come out into the second passage, fifty feet from its starting point. From here onward for 210 feet the lower passage leads through a water-worn crevice from two to four feet wide and three to fifteen feet high, the stream sometimes covering its bottom, and again running in a channel cut beneath one or the other of the sides. Three hundred feet from the cave entrance this passage ends abruptly in a room fifty feet high and ten feet wide, the sides converging in an angle to form the roof. On the left, about twelve feet from the floor, is an arched opening, and through it comes a roaring sound of falling water. With difficulty we climb a slippery bank, and, passing through this opening, find a most magnificent scene for so small a cave—a great cylindrical pit or shaft, twenty feet in diameter and sixty feet high, down which, on the farther side, falls a stream of water. A large bowl-shaped cavity twelve feet deep has been worn by the falling water in the limestone below the level on which we stand. Descending into this, we find that the stream flows out through a passage to the left, too low for exploration.

Returning to the vestibule we climb to the entrance of the upper floor, and, passing a short distance within it, find two passages diverging. One to the left, but forty feet in length, ends blindly against a bank of hard clay. Here had been, in days of yore, a bear wallow, and the marks of bruin's claws were numerous and plainly visible in the clayey walls. The right hand passage proved a long and tortuous one, and had a number of short branches leading from it, one of which showed plainly the evidence of former inhabitancy by bears. This main upper passage is in most places seven to ten feet high, with a width of five to seven feet. Two hundred feet from the vestibule it became necessary to crawl for about thirty feet through a space one foot high by two feet wide, when we emerge into a circular room thirty feet in diameter by three and a half high, the floor of which contains a vast amount of bat guano. Beyond this the passage forks into three branches, each of which was explored as far as possible, the longer one reaching 400 feet from the vestibule before its small size barred farther progress. The floor of this upper cave was covered in many places with a yellow ochery clay. In this, in several places, were found some handsome acicular crystals of selenite. No water was found on the upper floor, except at the farther end of the galleries where it stood in shallow pools. These places were evidently quite near the outer surface, as the shells of several land snails were found near by the water.

FAUNA. No vertebrates were seen in Eller's Cave, though, as in many others visited, the signs of out of-door mammals were plentiful.

Of crustaceans, two species, *Crangonyx gracilis* Smith, and *Cæcidotæa stygia* Packard, were found in small numbers at several localities in the stream of the lower floor. No myriapods nor adult beetles were noted, though near the end of the upper gallery a number of the larvæ of *Quedius spelæus* Horn, were found beneath a pile of the excrement of raccoons. Some half grown specimens of *Meta menardi* Latr. represented the spider family. Thysanurans, *Degeeria cavernarum* Packard, were plentiful, while of Diptera, a number of specimens of *Blepharoptera specus* Aldrich, were secured. For a cave as well watered as it is the fauna was exceedingly limited, though a longer stay would doubtless have revealed a number of additional species.

SALTPETRE CAVE,

Monroe County, is located in the northwest quarter, section 15 (township 8 north, range 2 west), about six miles southwest of Bloomington. The cave has a rather large entrance, it being twenty-five feet wide and four and a half feet high, with the floor descending for twenty or more feet. Fifty feet in it narrows to eight feet in width, and 150 feet from the entrance the roof comes down to within three feet of the floor, and a ditch has been dug for a distance of forty feet to facilitate passage to the large room immediately beyond. This room is fifty feet wide by sixty feet long, with the roof flat and the floor on the farther side sloping down at an angle of about forty-five degrees to a deep hole, called the Devil's Pit, which has a diameter of twenty-three feet, with the bottom thirty-five feet below the main floor of the room. From this pit one passes onward through an arched doorway into a narrow passage twenty feet high and five feet wide, between great masses of limestone. In one place this passage is partly filled by an enormous mass of fallen rock, over which one has to climb and descend on the farther side by a rude ladder, or, rather, pole with slats nailed across it. Beyond this the passage narrows into a crevice forty feet high and three feet wide, and finally enlarges into a small room, from which a low water passage alone extends. The entire length of the cave admitting exploration is thus but about 400 feet. Retracing our steps toward the mouth, we find on the right side of the main room an opening near the top, which leads into an alcove or small circular room, twenty feet in diameter and ten feet high, the floor being about on a level with the ceiling of the large room adjoining. The walls of the small room have an intercalary stratum of shale between two layers of limestone. In many places the lower stratum of limestone has dissolved away and the shale has decomposed into a soft unctuous clay containing many fine crystals of selenite. The large room of the cave has its floor partially covered with a deposit of "nitre earth," or red clay, which by lixiviation yields about 6.5 per cent. of potassium nitrate. In the early settlement of the country this deposit is said to have been utilized and the nitrate used in the making of gunpowder, whence the name of "Saltpetre Cave."

FAUNA. No water was found in the cave, hence animal life was scarce. A few specimens of the "little brown bat" were seen clinging to the ceiling, and the dens and characteristic odor of foxes were noted in several places. The Thysanuran was plentiful in a few of the damper spots on the floor. Of Diptera, but two species, *Blepharoptera pubescens* Loew and *B. specus* n. sp., were found on the walls, while a few specimens of the most common cave spider, *Meta menardi*, was the sole representative of the *Arachnida*. No beetles, myriapods or crustaceans were seen.

SHILOH CAVE.

The entrance to this cave is at the bottom of a sink hole a few rods north of Shiloh Church (northwest quarter section 18, township 5 north, range 1 west), about seven miles northwest of Bedford, Lawrence County. Except after a heavy rain, no water flows through the entrance, but a stream runs the entire length of the main cave, entering it from beneath a great mass of fallen rock which has partially closed the entrance, and meandering from side to side on the floor in its onward course. On entering, one descends rapidly for about twenty-five feet, and then reaches the general level of the main passage. This passage is from fifteen to twenty-five feet high and about the same width for 2,000 feet, which was as far as it was explored, the water becoming too deep to wade beyond that point. It far exceeded any of the previous caves visited in the number and size of its stalactites and stalagmites, many of which were of exceeding clearness. In the words of Prof. John Collett, who visited the cave in 1873, "the lofty sides are draped and festooned with stalactites, sometimes hanging in graceful folds or ribbed with giant corrugations. Above, the roof and overhanging sides bristle with quill-like tubes, fragile as glass, each tipped with a drop of water which sparkles in the lamplight like a crystal jewel."

Three hundred feet from the entrance three jets of water pour down from the right wall of the cave, and add to the size of the stream along its floor. These falls vary in height from seven to ten feet, and together they produce a roaring sound which is echoed far along the main passageway.

From this point onward the walls are dripping more or less and are fringed with small stalactites. About 900 feet from the entrance are two large stalagmites, one of which, named by Collett "The Image of the Manitou," has been broken. Originally it must have been six feet in height and eighteen inches in diameter.

Several branches leave the main passage but all but one are short in length. The one exception turns to the right about 1,500 feet from the entrance and extends in a southwesterly direction. At first it is a high, narrow fissure with the jutting walls bearing many stalactites. A stream of water covers the entire floor, and from far in the distance comes a murmuring sound caused by a succession of water falls, four in number and in size small, which occur at short intervals along the passage. Wading through pools, clinging to corners of jutting ledges, climbing over slippery, perpendicular banks we make our way until finally the passage begins to rise, and the limestone gives place to a dark shale, and this in time to a light colored clay. We are 900 feet from the fork and think we are nearing the surface and will soon find our way above ground, when all at once our lights go out and we stagger backward through utter darkness, escaping, as if by a miracle, the clutches of the deadly choke-damp which lurks for unwary explorers amidst the deepest recesses of this cave.

Beyond the point where this right branch leaves it, the main passage continues in a southerly direction and was explored until the back water from the dam at the mouth of the cave became too deep to wade. As we were preparing to leave the cave a heavy thunder shower came up, and the water soon poured in torrents through the sink hole, and adding its volume to that of the enlarged stream within the cave, soon covered the entire floor to a depth of nearly two feet.

Leaving the cave after the shower had subsided, a visit was made to the mill at its mouth. This is located in one of the ravines or breaks of Salt Creek, about two-thirds of a mile south of Shiloh Church. Here a heavy wall of masonry has been built across the mouth of the cave, which is on the hillside, forty feet above the mill. This dams the water back until it entirely fills the cave for quite a distance. In wet seasons the water is sufficient to grind full time, but in dry seasons the mill often has to be shut down for several days to allow the water to "head up."

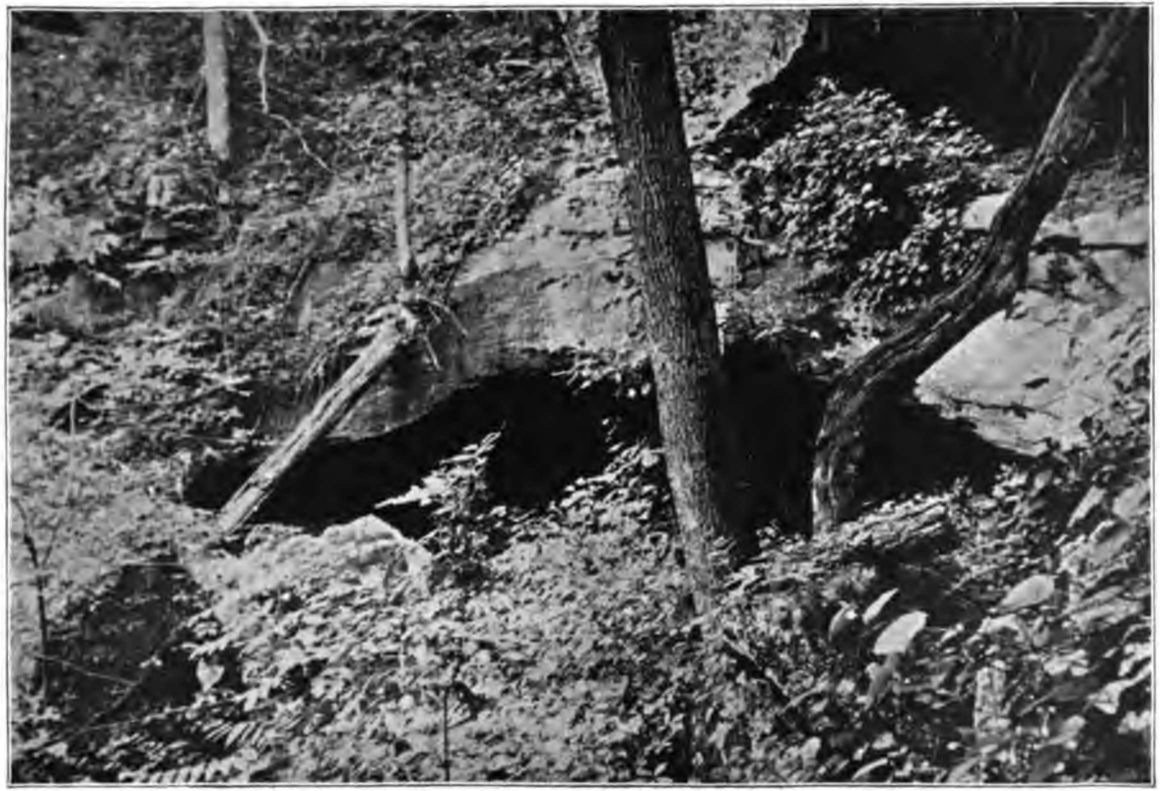
FAUNA. Professor Collett reported the animals inhabiting Shiloh Cave as "coons, rats and ant-lions." None of these were seen by the writer, nor were any vertebrates noted. Of crustaceans, the blind crayfish, *Cambarus pellucidus* (Tellk.), was quite common in the pools of the stream flowing through the cave. Two small aquatic Hemiptera-Heteroptera of the genus *Corixa* were taken, by dredging, about 350 feet from the entrance. These were the only specimens of Hemiptera taken in Indiana caves.

A single specimen of the true cave beetle, *Anophthalmus tenuis* Horn, represented the Coleoptera; while of Diptera, *Blepharoptera pubescens* Loew, and two new species, *B. latens* and *Mycetophila umbraticus*, were secured. A single myriapod, *Lithobius sp.*? and a stone cricket, *Ceuthophilus maculatus* (Harris), completed the living forms noted in the cave.

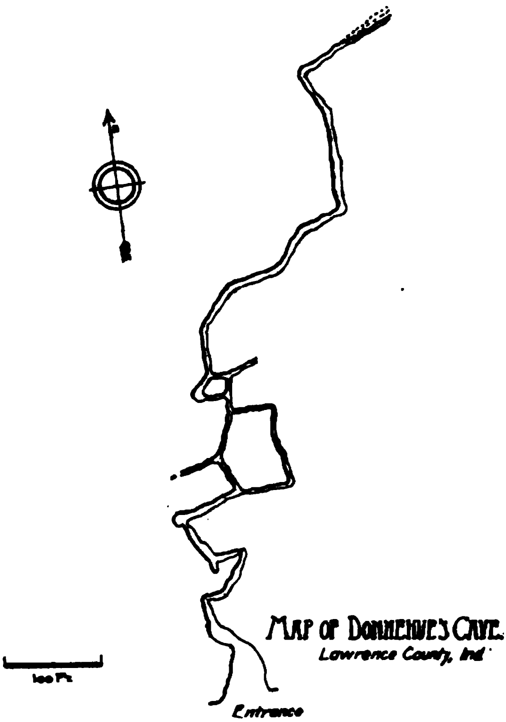
DONNEHUE'S CAVE.

The mouth of this cave is located near the foot of one of the bluffs of White River, 500 yards distant from that stream and two and one-half miles southwest of Bedford, Lawrence County, in the southwest quarter of section 27 (township 5 north, range 1 west). From the mouth of the cave a small stream finds its way, the source of which is in a sink hole three-fourths of a mile distant in a northeasterly direction. The stream is greatly enlarged after a heavy rain, and by its erosive action the cave is constantly but slowly increasing in size.

PLATE VI.



THE ENTRANCE TO DONNEHUE'S CAVE, LAWRENCE COUNTY, INDIANA.



Entering the cave, one finds himself in a commodious room, 10 feet high and 48 feet in width, the floor of rock, covered in places to a depth of two or three feet with alluvial drift Fifty feet back this narrows to 12 feet in width, and a short side passage puts off to the left, in which a number of the cave salamanders were found. Back 180 feet from the mouth, the passage was 6½ feet high by 6½ feet broad, the stream on the floor about three feet in width and three inches deep. Farther on this stream deepens and several pools were found in which the water was two or more feet in depth. At a distance of 325 feet the main passage forks, and from the right-hand branch so strong a current of air came that it was impossible to use candles and lanterns had to be substituted. The change in lights made, the right-hand passage was found to be a narrow, winding one, about 150 feet in length, and to lead back into the main passage about 100 feet farther from the mouth than the point from which it started. All these branches are through the solid rock, and are only water channels, three or four feet high and about as wide.

Beyond 425 feet, several side branches were found to contain water too deep to wade, or to soon become too low for further progress; in fact, the rock is more honeycombed with small passages than in any cave visited. The main passage, however, at about 500 feet from the mouth, enlarges to a height of 40 feet and a width of eight to ten. This portion is for the most part dry, the stream having disappeared in one of the low channels already mentioned. In some places two floors are found, in others the greater part of the upper floor has fallen in, leaving a portion in the form of a natural bridge, spanning the passage from side to side. At a point 950 feet from the mouth the upper passage ends against a perpendicular wall of rock, from near the top of which was a passage onward, but too high from where we stood to admit of entrance. The lower passage was followed to about the same point, where it became two feet high and three feet wide and almost filled with water, thus barring further progress. But few stalactites are found in the cave, and they are mostly of small size and unattractive appearance.

FAUNA. The cave salamander, *Spelerpes maculicauda* (Cope), was found to be more abundant in this cave than in any previously visited. Several were back 300 feet or more from the mouth, though most were taken about fifty feet therefrom. No bats or other mammals were noted, though tracks of raccoons and minks were plentiful. Although the conditions for aquatic forms seemed most favorable, with the exception of the single shrimp-like crustacean, *Crangonyx gracilis* Smith, none were seen. Blind crawfish had been previously found in this cave by W. P. Hay, but the raccoons, or something else, had caused their total disappearance in those portions of the cave explored by us. Of spiders, one species, *Meta menardi* Latr., was very plentiful; and of Diptera, four species were taken, as follows: *Sciara sp?; Blepharoptera latens* and *specus*, two new species described hereafter by Aldrich; and *Limosina tenebrarum*, also new to science. This last species was found in company with a number of the larvæ of the cave staphylinid, *Quedius spelæus* Horn, inhabiting a large pile of coon dung in a recess of the cave, 350 feet from the mouth. Here also were taken a number of specimens of the mature beetles *Quedius fulgidus* Fabr. and *Q. spelæus* Horn, as well as an earthworm as yet undetermined. No myriapods or thysanura were noted in the cave.

HAMER'S CAVE

has its mouth on the side of a hill at the head of a deep valley in the southeast quarter of section 32 (Tp. 4 N., R. 1 E.) three miles east of Mitchell, Lawrence County. Near the head of this valley and close to the mouth of the cave are the ruins of an old stillhouse and a large deserted stone mill, both of which were formerly run by the stream of water which rushes with great force through the mouth of the cave fifty feet higher on the hillside. At the time of our visit the dam at the mouth of the cave was still intact and the water behind it filled the cave to a depth of four feet or more, so that exploration was impossible. From the mouth and through a wooden flumeway extending to the mill, the water was rushing with great speed. According to Prof. Collett (Ind. Geol. Survey, 1873, 303), the floor, a short distance within the cave, was at that time "level, six feet wide and covered with a swift stream of water eight inches deep, although at places the depth is increased to twenty feet. A boat of course is needed for exploration. Three-quarters of a mile* from the door is the first fall. The whole stream rushes down an incline only three feet wide with great violence and a noise that fills the cave. The boat must be carried above this obstacle, when another voyage is taken along a space of 300 feet to the second falls or 'grand cascade.' Beyond, the cave is low, wet and full of rushing water, which flows out of a crevice in the rock. Eyeless fish, crawfish and other crustaceans are found in this and the two adjoining caves which have outlets in the grand amphitheater in which the mill is situated."

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*Distance guessed at and probably not over 250 yards.— W. S. B

DONNELSON'S CAVE.

Among Indiana caverns the mouth of Donnelson's Cave ranks next to that of Porter's in picturesque beauty. Indeed, by some it is classed as more attractive. The mouth of the cave is found at the head of a deep gorge worn through the limestone by a good sized stream which flows from the cave and down the gorge to the broader valley beyond. Many centuries ago the cave extended the full length of the gorge, and the waters of the stream flowed directly from its mouth into the valley. The roof of the underground channel finally became so thin that it collapsed, the gorge was then started, and as the centuries went by grew in length, the cave ever becoming shorter by the continued falling of the roof. Both gorge and cave are located in the southeast quarter of section 33, township 4 north, range 1 east, about three-fourths of a mile east of Hamer's mill.

Three passages open directly into the mouth of the cave. The right hand passage has the level of its floor about five feet above that of the entrance, while the opening on the left is 12 feet above the bed of the stream and very difficult to enter without a ladder. The middle passage extends straight back from the common vestibule or main entry. The latter is twenty-five feet long, twenty-one feet high and eighteen feet wide, but at its farther end is reduced to the narrow middle passage between great masses of limestone. The water in this passage is waist deep and explorations must be made by wading or in a light canoe. One hundred feet within is a magnificent cascade, where the stream rushes and leaps down a narrow passage with such violence that the noise is plainly heard at the entrance.

The right-hand passage for the first 100 feet is about ten feet high by fifteen wide, with a clay bottom and a roof on a level with that of the vestibule. It then expands into a large room, 230 feet long and forty feet wide, which lies east and west at right angles to the entering passage. This narrows at the west end to twenty feet, and at one point the outer air flows in through a small opening in the roof. From near the small end of the room a narrow passage starts off to the southward and can be traveled for 200 feet, when it becomes too small for further advance. Along this passage a small stream flows, disappearing through a hole in the floor near the entrance to the larger room. Other than this, both right and left passages leaving the main entry are dry.

The passage at the left of the main entrance to the cave is about 150 feet long by twenty broad, and contains no points of especial interest. No stalactites worthy of notice are found in this cave. It is said that about the year 1800 the nitrous earth on the floor of the two dry passages was used in the making of saltpetre; and the stream flowing from the main cave was afterward dammed and utilized in driving a woolen, grist and saw mill.

FAUNA. The blind fish, *Amblyopsis spelœus* DeKay, is said to inhabit this cave, but none were taken or seen by the writer, though a number were secured in a near-by cave, which probably is connected with this.

Among crustaceans, the blind crayfish, *Cambarus pellucidus* (Tellk.), and the small *Caecidotœa stygia* Packard, were secured. Of spiders, two forms, the common *Meta menardi* Latr., and an above-ground species, *Dolomedes urinator* Hentz, were taken. Of flies, two species of *Blepharoptera* were seen on the walls of the dry rooms. No beetles or myriapods were taken.

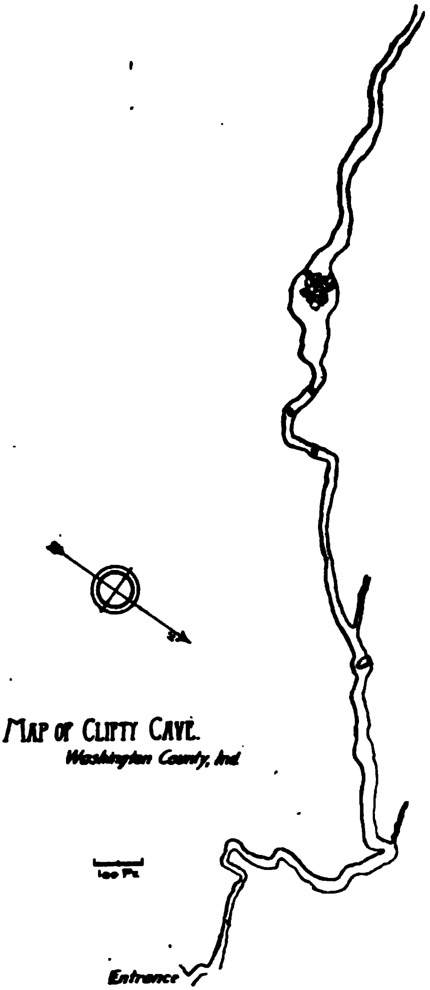
CLIFTY CAVES.

The mouths of the two Clifty caves are about 200 yards apart, and are located at the head of a deep and narrow valley in the east half of section 14 (township 3 north, range 2 east), about three miles north of Campbellsburg, Washington County, Indiana. Clifty Creek has its source in the streams which emerge from the caves, and flows in a northwesterly direction about four miles to White River, into which it empties. Its valley, especially the upper half, is noted for the wild and rugged scenery, and the vicinity of the caves is a noted resort for pleasure seekers.

The caves are designated, respectively, by the terms "wet" and "dry," the former being the smaller of the two. Across the mouth of the wet cave a dam has been built, and the water emerges from it in sufficient force to turn the machinery of a distillery and grist mill, both abandoned, however, since their owner died, a few years ago. The mouth of the cave is a perfect archway in the solid limestone, fourteen feet wide and eleven feet from roof to bottom. The water behind the dam was two and a half feet in depth, and deepened rapidly as one went back, and the cave was explorable only by boat, which we did not possess.

In Packard's "Memoir of the Cave Fauna of North America," p. 16, is an extract from a report on a visit to these caves by Dr. John Sloan, of New Albany, in which he states that he went up the stream in the wet cave for about 200 yards on a raft of timber, at which point rapids were encountered, over which it was impossible to lift the raft, and the water above being too deep to wade, he was obliged to return.

The "Dry Cave" was explored by our party for a distance of 2,650 feet, beyond which it was impossible to proceed. The entrance is larger than that of the wet cave, being eighteen feet high and twenty feet wide. Back 100 feet it narrows to thirteen feet in width, and, fifty feet farther, to about eight feet, the water at this point covering the entire floor to a depth of six inches. For the first 500 feet the main passage is very crooked, but beyond that point it is comparatively straight and extends in a general southwesterly direction. Like Mayfield's cave, it is a mere water-worn passage, with no large rooms, few stalactites, and, in general, may be said to be monotonous. The stream on the floor winds from side to side of the cave, thus making the frequent crossing of it necessary.



Several short side branches diverge from the main one, and at a distance of 1,300 feet from the mouth a larger branch turns off to the right, which was explored for about 400 feet, but not to the end, as our time was limited. The main passage continues to the left, and at 1,800 feet we found a large rock, 30 x 15 feet, which had fallen from the roof and partially blocked the way. Two thousand feet from the entrance the passage widens into a room 100 feet across and four feet in height, which contains much fallen rock, but nothing else of especial interest. Beyond this the cave narrows again and varies from twenty to thirty feet in width, as far as explored.

FAUNA. Dr. Sloan states, *loc. cit.*, that blind fish are found in the "Dry Cave," but, though especial search was made for them, none were seen. Several cave salamanders, *Spelerpes maculicauda* (Cope), were taken from the damp walls within 100 feet of the entrance. Bats were seen in small numbers hanging from the roof, and signs of "coon" were plentiful.

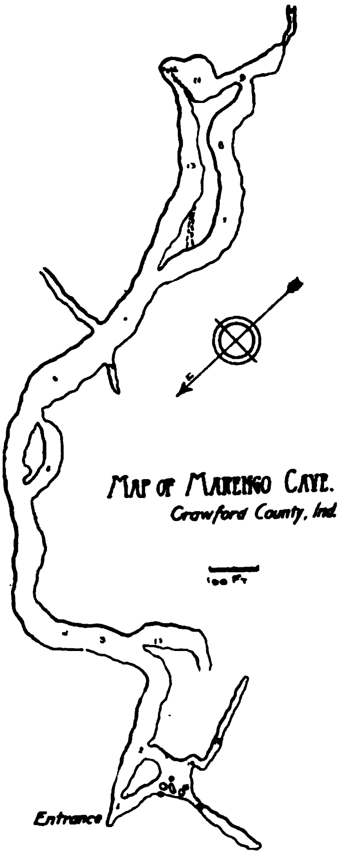
One blind crayfish, *Cambarus pellucidus* (Tellk.), and a large number of seeing ones, *C. bartonii* Fab., represented the crustaceans, both forms being taken from the same locality, about 1,200 feet from the mouth. No myriapods or thysanura were seen. Of Arachnida, the cave spider, *Meta menardi* Latr. was common, hanging from a single thread attached to the roof; and a few specimens of the cave harvestman, *Scotolemon flavescens* (Cope), afterward found abundantly in Wyandotte Cave, were secured. Several young and one mature specimen of the cave beetle, *Quedius spelœus* Horn, were taken from some refuse matter, 600 feet from the entrance, and a representative of that common above-ground carabid, *Harpalus pennsylvanicus* De Geer., was taken by the side of the stream flowing through the left branch, 1,400 feet from the entrance. It had probably been washed in by some of the heavy rains the week before. The only additional forms taken were Diptera, three species of *Blepharoptera* being found on the walls, and a small gnat-like form, *Limosina tenebrarum,* n. sp., from some refuse matter, 600 feet from the mouth.

MARENGO CAVE.

This cave, which next to Wyandotte is the most noted in Indiana, is located in the northwest quarter of section 6 (township 2 south, range 2 east), a short distance northeast of Marengo, Crawford County. The L. E. & St. L. Railway ("Air Line") passes through Marengo, and the entrance to the cave is less than one mile from the station.

Marengo Cave has been known only since 1883, and the owners of the land on which the entrance is located, were wise enough to prevent the ruthless destruction of the stalagmites and stalactites which form the main beauty of the cavern. Some children playing about a sink hole in September of that year, noted an opening which had been formed near its bottom by a recent falling of earth and rock, and, venturing in, found the room now known as "Grand Entrance Hall." Afraid to go farther, they made known their discovery to other persons, and in a few weeks the entire cave had been explored. A building was soon afterward erected above the mouth, and stairways built, so that entrance into the cave could be easily and safely made.

Thousands of visitors have since passed through the cave, and no one who is at all in sympathy with nature can come forth from its corridors and passages without feeling fully repaid for his peep into one of her underground chemical workshops There the only materials necessary are water and limestone. Given these and time unlimited, and the varied character and wonderful beauty of the products possible can only be realized by those who have spent a few hours in a cavern like Marengo.



1. Grand Entrance Hall.
2. Cut Off.
3. Congress Hall.
4. Mammoth Hall.
5. Elks' Hall.
6. Music Hall.
7. Cave Hill Cemetery.
8. Creeping Avenue.
9. Junction Room.
10. Fairy Palace.
11. Prison Cell.
12. Prison Bars.
13. Washington Avenue.
14. Lovers' Retreat.
15. Nameless Pass.
16. Crystal Palace.
17. Crystal Palace Gallery.
18. Pillared Palace.
19. Western Avenue.

Descending the stairway, after having been provided with a lantern and guide, the visitor finds himself sixty feet below the surface in the large vestibule known as the Grand Entrance Hall. This is a room 50 feet wide, 20 to 30 feet in height, the floor of dry earth, and with two passages diverging, one ascending to the right and leading through the Short Route and Crystal Palace, the other descending to the left and leading through the Long Route.

Taking first the latter, we find the main passage to be 12 feet high and about 50 feet wide. Scattered at intervals along its walls and roof are many stalactites, some in groups, others singly, and all possessed of fanciful names given them by former visitors or by the proprietors and guides of the cave. One hundred feet from the foot of the entrance is a slab of limestone, fallen from the roof, whose dimensions are 18 x 8 x 4 feet. This is known as Fallen Rock, and beyond it a short distance is, on the right, a passageway known as the "Cut Off," which leads to the Crystal Palace. Continuing, the main passage widens to 30 or more feet, and for a distance of 80 feet is known as Statue Hall. In it are some noteworthy formations, the prettiest of which is Mt. Vesuvius, a large, rounded stalagmite. Above it is a group of slender stalactites, down which a stream of water trickles and gives a muddy character to the floor for a distance of several hundred feet. From the side of the roof, on the right, hangs a group of stalactites, their bases thin, wide and overlapping, the whole resembling somewhat a bunch of "long green," whence the name of "Tobacco Shed" given to this formation.

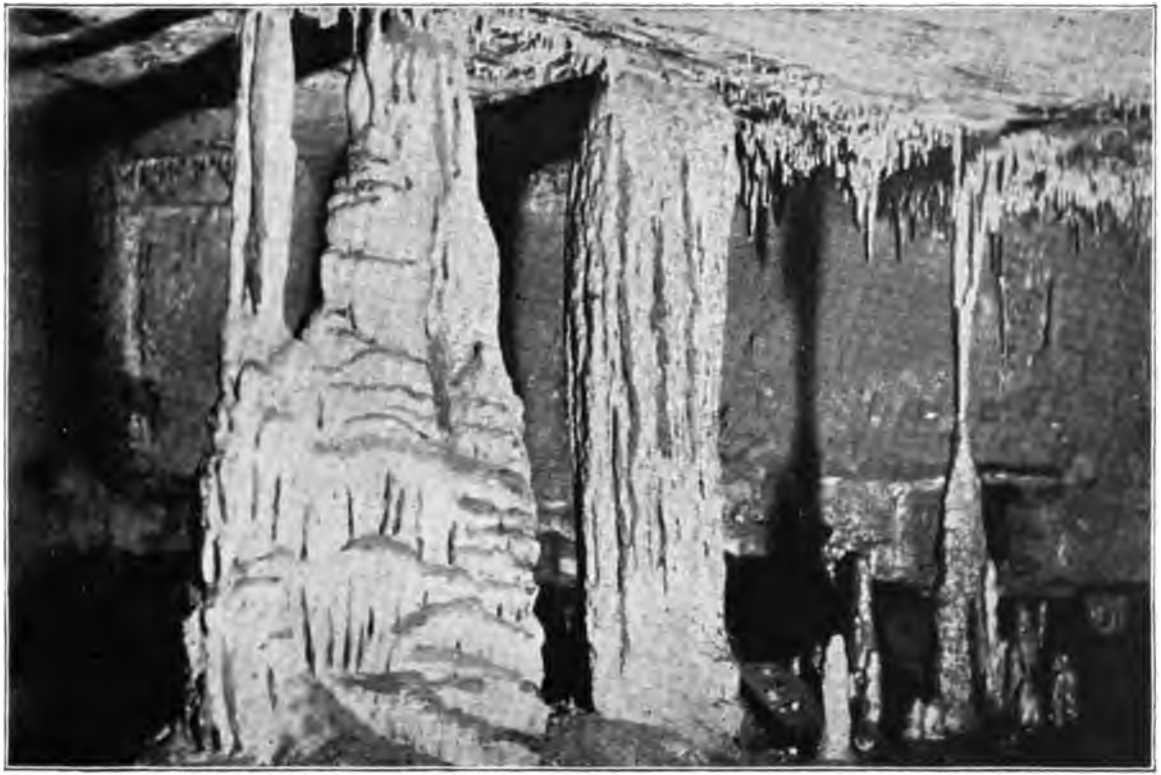
Congress Hall succeeds Statue Hall, and contains along the edge of the ceiling some handsome formations, known as the Giant's Mitten, Mammoth Pen, etc. From this hall the bed of an old stream leaves to the right beneath the massive limestone walls. Mammoth Hall, with a width of about sixty-five feet and a length of 300, comes next in order, and contains the Elephant's Head, Folded Lamberquin, Bridal Curtains and other fantastic formations of carbonate of lime, wrought in darkness in ages past.

Beyond Mammoth Hall the passage divides and passes around a mass of uneroded limestone. The branch on the right rises ten or fifteen feet above the level of the main floor and enlarges into Elk's Hall, a room 190 feet long and twenty feet high, which was dedicated and named, as an inscription on the walls informs us, by Louisville Order, No. 8, B. P. O. E., September 27, 1885.

The two branches converge again, and at a distance of 1,000 feet from the entrance enlarge into Music Hall, a large room containing a raised platform of rock, known as the Band Stand. A short distance farther on, a branch goes off to the left which has been explored only by guides, the ceiling being low and the scenery possessing no especial interest.

Fourteen hundred feet from the entrance the main passage again forks the right branch containing Cave Hill Cemetery. Herein are found some beautiful stalagmites and pillars, one of which, called Washington's Monument, is among the most striking objects of the cave. Its height is four feet eleven inches, and a foot above the base it is two feet in circumference. Composed of the clearest of crystalline limestone, it stands with its white surface gleaming in the dim lantern light, inspiring the visitor with a feeling of wonder as to how an object of such beauty and purity could have been formed in these depths of Cimmerian darkness. Another monument of greater size, but less imposing, on account of its yellowish brown color, is the Tower of Babel—ten feet high and six feet eight inches in circumference. It stands among numerous smaller stalagmites, a short distance beyond Washington Monument.

Beyond the Tower of Babel the roof of the right branch lowers, and we crawl through a narrow opening and then creep or stoop for quite a distance through Creeping Avenue, passing meanwhile among many pillars, stalagmites and stalactites, varied in form and beautiful to look upon. We emerge and stand erect 2,000 feet from the entrance, in the Junction Room, where the branch which turned to the left at the entrance to the Cave Hill Cemetery meets the right branch through which we have traveled. Beyond this point the cave narrows and the roof comes down within a foot of the floor. By creeping, crawling and twisting from side to side we manage to get up a slippery hill and through a small opening into



"ADAMS EXPRESS CO." AND "PILLAR OF CONSTITUTION," MARENGO CAVE, CRAWFORD CO., IND.

the Fairy Palace, a place visited by few on account of the difficulty of the way. Here we find the farthest explored part of the cave, and in the small room, perhaps ten feet wide and five feet high, are thousands of formations, which reflect our light in a most brilliant manner. Retracing our way to the Junction Room, we turn to the right into the Prison Cell, a large room which contains some of the principal features of the cave. Here is the Leaning Tower of Pisa, a stalagmite six feet high, with the top inclined several inches beyond the base; Solomon's Temple, a group of slender pillars six and a half feet in height and arranged in a circle; Administration Building, a pillar made up of a series of circular layers of crystalline limestone, piled one on top of another so as to cause the whole to resemble a Japanese pagoda; Bunker Hill Monument, formed on a fallen slab, story on story as the preceding, besides many others as handsome, yet too numerous to mention. We pass from the Prison Cell, between the Prison Bars—a series of slender columns six feet long and six to eight inches in circumference—into Washington Avenue, the left branch of the main passage at the fork near Cave Hill Cemetery. This avenue is 450 feet in length, from twenty-five to forty in width, and for about one third of its length the ceiling is so low as to require a stooping position in passing through. On the way are many small stalagmites grouped in a straggling fashion, Grant's Army and Coxey's Army being the names given to two of the largest assemblages. The floor of Washington Avenue is dry and for the most part composed of earth, with here and there a slab of fallen rock. Near the fork it descends for about fifteen feet, and we enter once more the main passage, already described, and make our way along it to the "Cut Off" leading to Crystal Palace, passing on our left the Lover's Retreat, a winding cleft which extends about seventy-five feet back into the solid limestone.

The Crystal Palace is the crowning glory of Marengo Cave. It is a small alcove or side room, ninety feet long, fifteen feet wide and about twenty-five feet in height. At the south end is a perpendicular wall along which is a drapery or vast sheet of stalactites, and from a projecting shelf are many slender stalagmites, the whole so grouped as to resemble a giant pipe organ. The side walls are studded with hundreds of small and large formations, while from the roof hang pendent myriads of slender stalactites of the clearest crystal, which reflect with sparkling brilliancy the rays of the calcium or magnesium flash lights. By ascending a stairway fifteen feet, one finds himself on a balcony in the very midst of these formations and can pass back into Crystal Palace Gallery, a low passage, about 150 feet in length, the floor of which resembles a relief map, being thrown up in many places in narrow corrugations and ridges, with here and there a pool of limpid water occupying the irregular and shallow depressions.

Descending the stairway and passing to the left, we enter the Western Avenue or Short Route, the principal feature of which is the Pillared Palace, where giant pillars, stalactites and stalagmites are so numerous that it is with difficulty the visitor winds his way between and around them. This portion of the cave extends but about 150 feet in a westerly direction, and into it has been dug an artificial opening from the surface, forty feet above. Retracing our steps for the last time, we turn to the left at the mouth of the Pillared Palace and pass through another bower of beauty, the Queen's Palace, a small room, whose walls are composed wholly of pillars and stalagmites. Beyond this we pass the Diamond Dome, the largest stalagmite of the cave, thirty-one feet in diameter and reaching from ceiling to floor, and emerge into Grand Entrance Hall, which was our starting-point.

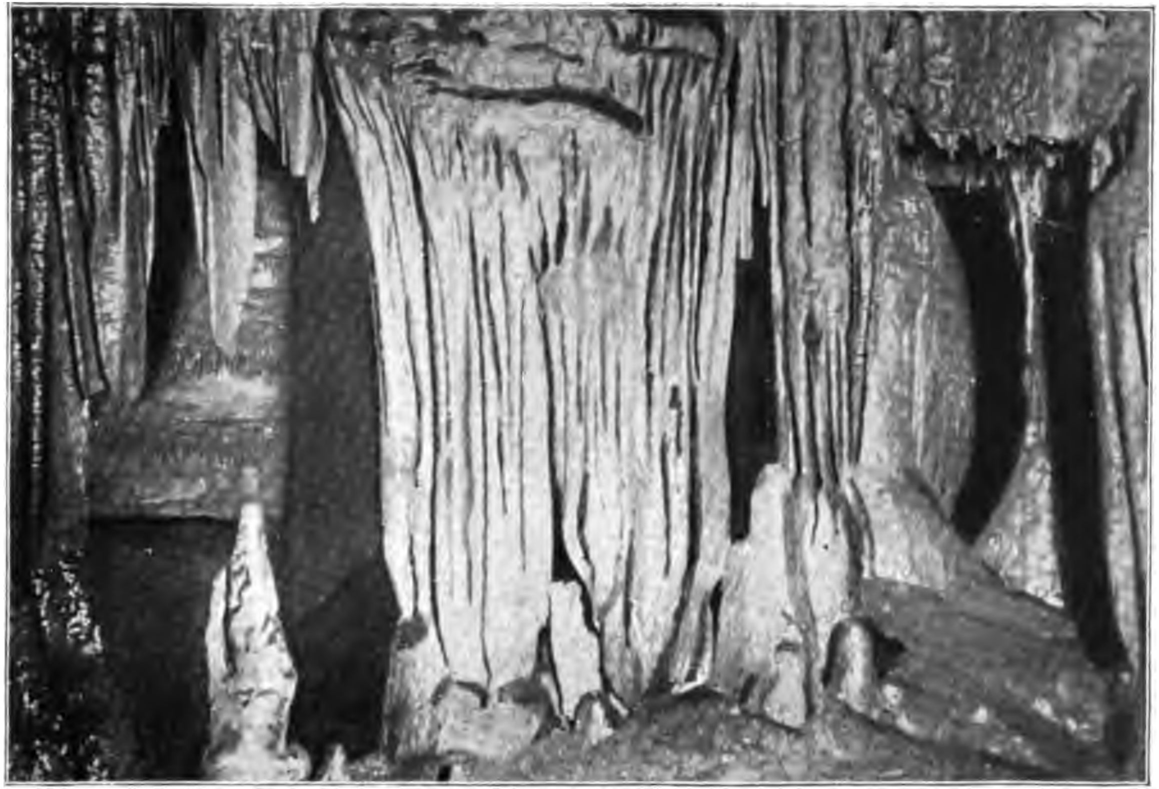
The total length of Marengo Cave, including the side branches through which we passed, was as follows:

Long Route, foot of stairway to Junction Room	1,950 feet.
Junction Room to end of Fairy Palace	175 feet.
Junction Room to Prison Bars	200 feet.
Washington Avenue	450 feet.
Lover's Retreat	75 feet.
Elk's Hall	190 feet.
Nameless Pass	150 feet.
Cut-off	100 feet.
Crystal Palace and Gallery	250 feet.
Short Route to place of starting	310 feet.
Total	3,850 feet.

Within this distance of less than three-fourths of a mile are probably crowded more beautiful formations of crystalline limestone than in any other known cave of similar size in the United States.

Lacking the length, the lofty vaulted rooms and the grand scenery of Wyandotte, Marengo far excels that cave in the abundance and beauty of its stalactites, stalagmites and other cave formations. To those who wish but a glimpse of underground life, we most heartily commend it, believing that a visit of a few hours will repay all who take an interest in the mysterious and beautiful in nature.

Fauna The fauna of Marengo cave is not as varied and as numerous as one would suppose. The short time that has elapsed since the cave was opened and the erection of a building above the entrance have prevented many forms of life from entering and taking up their abode therein. Of vertebrates, a form of the white-footed mouse, *Hesperomys leucopus* Raf., is frequent in the first 250 feet. Several were caught in cyclone traps, and, while possessing larger ears, longer whiskers and more protruding eyes than above-ground specimens, these variations were not definite enough to separate the form even as a distinct variety. The



ENTRANCE TO PILLARED PALACE, MARENGO CAVE, CRAWFORD COUNTY, INDIANA.

cave salamander, *Spelerpes maculicauda* (Cope), was taken at the side of the entrance, and is said by the guide to occur thereabouts at all seasons of the year. But one species of crustacean, *Cæcidotœa stygia* Packard, was secured. It was very plentiful beneath some pieces of boards in a pool at the side of the "Prison Bars." The blind crayfish is said to occur in some pools near Diamond Dome, but none were to be found at the time of our visit. The myriapod, *Pseudotremia cavernarum* Cope, so common in Wyandotte, is also plentiful in Marengo, and was the only member of the group there taken. Of Coleoptera, but three specimens of one species, *Quedius fulgidus* Fab., were secured. They were found within 250 feet of the entrance beneath a board used to bridge a damp spot. The Thysanuran, *Degeeria cavernarum* Packard, was plentiful and a single specimen of a larger, lead colored species was taken in company with the beetle above mentioned. Two species of Diptera, both new to science and one representing a new genus, were taken. They are described, in a paper accompanying this report, by Prof. J. M. Aldrich, under the name of *Limosina tenebrarum* and *Odontopoda* (n. g.) *sayi*. The former was taken in several other caves, the latter only in Marengo, 400 feet from the entrance. The only additional form of animal life taken was *Nesticus carteri* Em., a small spider, several specimens of which were found crawling over the damp rocks, 300 feet in the main passage. Three species of fungus, one thin, white, and spreading over the under side of boards, another spreading in large, thin, fan-shaped masses over rocks; and the third, a large stemmed toadstool, were taken about 400 feet within the cave.

WYANDOTTE CAVE.

Next to Mammoth Cave, Kentucky, Wyandotte is the largest cavern in the United States. Its enormous underground halls and vaulted domes, its gigantic fluted columns, and vast piles of fallen rock are unexcelled in any other American cavern. Its situation among the rugged hills which form the breaks of the Ohio River, in a country as yet primitive in character, where game is plentiful, and fishing in the clear waters of Blue River exceptionally good, makes it a most inviting spot for a summer's outing.

Around the hotel, situated on a commanding eminence in a natural wooded grove close to the cave, grow many forms of plant life which are strangers to central and northern Indiana, while in the cave dwell many sightless animals whose habits of life are yet unknown, so that the botanist and zoölogist may add to the study of the cavern itself, the pursuit of their favorite studies.

History. The records concerning Wyandotte Cave go back only to 1812. During the war with England the demand for gunpowder became so great that much of the nitrous earth in the caves of Indiana and Kentucky was utilized in the manufacture of potassium nitrate, or saltpetre, one of the principal ingredients of gunpowder. What is now called the "Old Cave," was the only portion of Wyandotte then known to the whites, and to it the name of "Indiana Saltpetre Cave" was given by a Dr. Adams who first preëmpted the land on which the cave was located, for the purpose of manufacturing saltpetre. He carried on the business on an extensive scale from 1812 to 1817, and remains of leaching hoppers, troughs, etc., can yet be seen near the mouth of the cave, and at "Saltpetre Cave," about a third of a mile distant. The close of the war made the "petre" business unprofitable, and Dr. Adams relinquished his claim.

In 1819 Mr. H. P. Rothrock, the father of the present proprietor, purchased the land from the Government, paying the prevailing price, one dollar and twenty-five cents per acre. He did not attach any value to the cave, but wished the land for the timber growing upon it, he having erected a sawmill on the banks of Blue River, about a mile from the mouth of the cave.

But little attention was given to the cave by the owner and the residents of the vicinity. In fact the latter considered it a nuisance and in 1843 succeeded in getting the State Legislature to pass a law compelling Mr. Rothrock to fence up the entrance, so as to prevent cattle from entering and licking the epsom salts, which the cave contains in abundance.*

The only published account of Wyandotte cave previous to 1850 which has come to my notice is found in Flint's Geography of the Mississippi Valley, 1833, p. 389, as follows:

"Like Alabama and Tennessee, Indiana abounds with subterranean wonders in the form of caves. Many have been explored, and some of them have been described. One of them is extensively known in the western country by the name of 'the Epsom Salts Cave.'

"It is not very far from Jeffersonville. When first discovered the salts were represented as being some inches deep on the floor. The interior of this cave possesses the usual domes and chambers of extensive caverns, through which the visitant gropes a distance of a mile and a quarter to the 'pillar,' which is a splendid column, fifteen feet in diameter and twenty-five feet high, regularly reeded from top to bottom. Near it are smaller pillars of the same appearance.

"The salt in question is sometimes found in lumps varying from one to ten pounds. The floors and walls are covered with it in the form of a frost, which, when removed, is speedily reproduced. The earth yields from four to twenty pounds to the bushel, and the product is said to be

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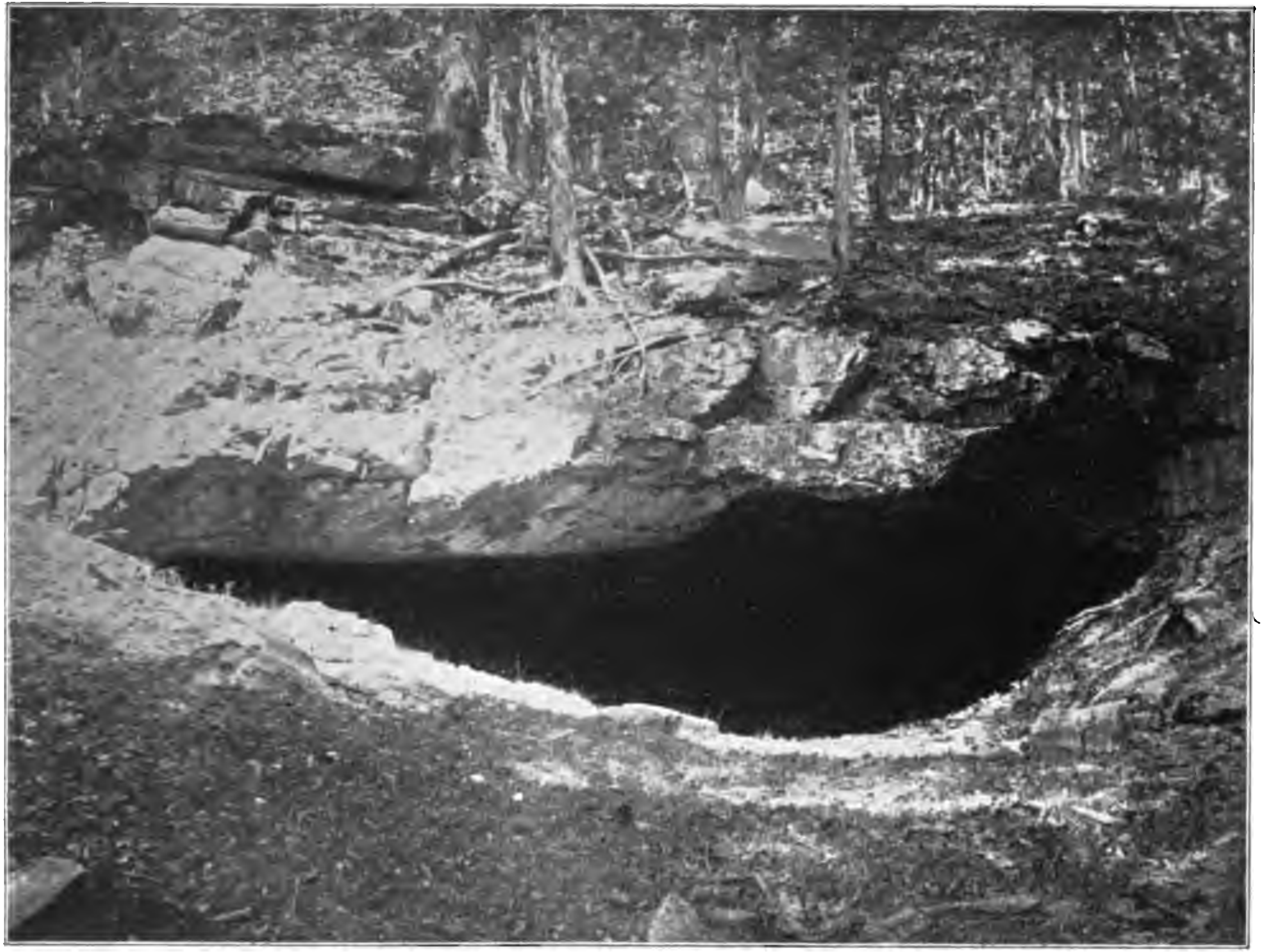
*Revised Statutes 1843, Chap. 53., p. 974, sec. 67.



THE ENTRANCE TO WYANDOTTE CAVE.

of the best quality. Nitre is also found in the cave in great abundance, and sulphate of lime or plaster of paris."

In 1850 a party from Fredonia, Ind., observing that a current of air was passing from beneath a large, loosely placed flat rock, 1,000 feet from the mouth and at the point at which the route of the "Old Cave" turns abruptly to the left, succeeded in prying the rock loose and found the opening since known as Fat Man's Misery. This they entered and passed through, and for the first time white men stood in the "New Cave." The "Long Route" was soon explored as far as the Sulphur Spring in Rothrock's Cathedral, and the "Short Route" to its present known limits About a year afterward a small opening through a stalagmitic formation by the side of the Sulphur Spring was observed, and by active use of hammers and drills was enlarged sufficiently for persons to enter. The opening was called the "Augur Hole," and through it explorers passed and made their way as far as the ends of Wabash Avenue and the Fairy Palace. In 1858 W. R. and J. G. McCollister enlarged the opening leading from the "Easter Room" and partially explored the passage now known as the "Unexplored Route." The next year Mr. G. J. Langsdale and Washington Rothrock finished the exploration of this passage as far as Rothrock's Island. This includes all the explored portions of the cave, with the exception of Milroy's Temple, which was discovered by a party of students from Wabash College in 1878. A number of descriptions of the cave have appeared in various papers, magazines and reports; a list of those which have come under the writer's notice being found in the bibliography at the end of the present paper.

The mouth of Wyandotte cave is located in the southwest quarter of section 27 (township 3 south, range 2 east), Jennings Township, Crawford County, Indiana. The nearest railway, the "Air Line," passes through Milltown, nine miles distant from the cave, over an exceedingly rough road. From Corydon, the county seat of Harrison County, the distance is about twelve miles, and the road a fair one for southern Indiana. This route is a most pleasant drive in the summer or autumn, and leads one down the romantic valley of Blue River. For several miles the road follows along the limestone bluff on the right side of that stream, in many places having been excavated in the side of the bluff forty or more feet from the water below. From Leavenworth, on the Ohio River, the nearest point for steamers, the distance is five miles.

The Cave Hotel is, according to measurements made by Professor Collett, 220 feet above Blue River, across whose narrow valley "Greenbrier Mountain, with sharp, conical peak and steep faces, belted with massive rings of rock, variegated with evergreen cedars, affords a scene of quiet, stately beauty."* From the hotel a pathway leads down a gradual slope to the mouth of the cave 100 yards away.

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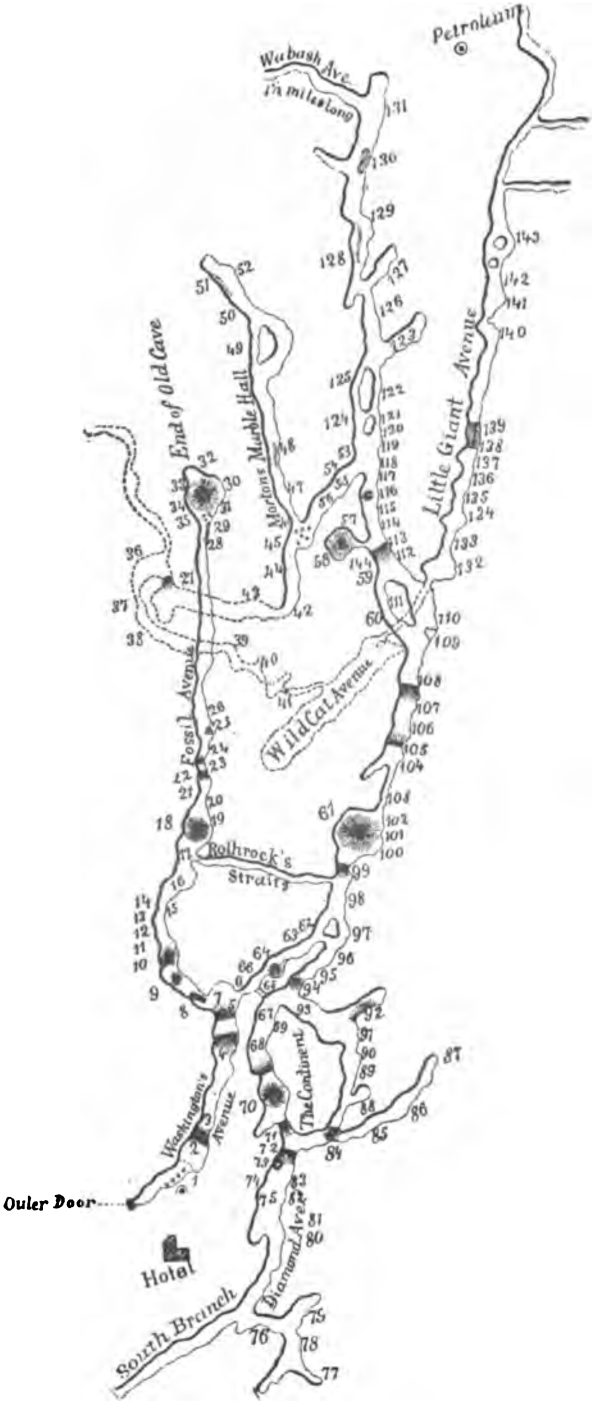
*Collett, Geol. Surv. Ind., 1878, 467.

WYANDOTTE CAVE.



0 Saltpetre Hoppers.
1 Arched Entrance.
2 Faneuil Hall.
3 Columbian Arch.
4 Falling Rock.
5 Wyandotte Chief.
6 Entrance to New Cave and Fat Man's Misery.
7 Banditti Hall.
8 Jacob's Ladder.
9 Pigmy Dome.
10 Debris Dome.
11 Continued Arch.
12 The Canopy.
13 Lucifer's Gorge.
14 Natural Bridge.
15 The Stoop.
16 Temple of Honor.
17 Secret Entrance to to Rothrock's Straits.
18 Odd Fellows' Hall.
19 Phantom Ship, "Millie."
20 Pharaoh's Stairway.
21 Conrad's Hall.
22 The Cliffs.
23 The Pit.
24 Falls of Minnehaha
25 Dead Fall
26 Cyclops' Chasm.
27 Dead Sea.
28 Screw Hole.
29 Polished Bowlders —Indian.
30 Senate Chamber.
31 Chair of State.
32 Pluto Ravine.
33 Stallasso Monument.
34 Stillo Mountain.
35 Pillar of the Constitution.
36 Heman's Bower.
37 Hine Cliffs.
38 Lonigan's Pass.
39 Diamond Labyrinth.
40 Emmonecy Arcade.
41 Rode Rock No. 1.
42 Queen Mab's Retreat.
43 Snow Banks.
44 Zoe Grotto.
45 Ice House.
46 Frosted Rock.
47 Snowy Cliffs.
48 Indian Footprints.
49 Beauty's Bower.
50 Queen Mab's Marble Garden.
51 Fairy Palace.
52 Wyandotte Potatoes—Pebbles.
53 The Arm Chair.

54 Lovers' Retreat.
55 Ewing Hall.
56 Frost King's Palace.
57 Bowlder Flints.
58 Milroy's Temple.
59 Penelope Grotto.
60 Ulysses' Straits.
61 Rothrock Cathedral.
62 Coons' Council Chamber.
63 The Rotunda.
64 Rugged Mountain.
65 Cut Off.
66 Counterfeiters' Trench.
67 Starry Hall.
68 Wyandotte Grand Council Chamber.
69 The Card Table.
70 Hall of Representatives.
71 Hill of Science.
72 The Alligator.
73 The Mound.
74 The Throne.
75 General Scott's Reception Room.
76 Anteroom.
77 Hovey Point.
78 The Pit and Sieve.
79 The Amphitheater.
80 Rocky Hill.
81 Muddy Fork.
82 Lost Rivulet.
83 Frozen Cascades or Curtains.
84 The Hippopotamus.
85 Fairy Grotto.
86 Neptune Retreat.
87 Hermit Cell.
88 The Sepulchre.
89 Purgatory.
90 Caliope Bower.
91 Palace of the Genii.
92 Pillared Palace.
93 Creeping Avenue.
94 Junction Room.
95 Drawing Room.
96 Dining Room.
97 Delta Island.
98 Sandy Plain, 300 feet long.
99 Hill of Difficulty.
100 Monument Mountain, 135 feet high, over which is Wallace's Grand Dome, 50 feet above top of Mountain, and 185 feet above base of the hill.
101 Sulphur Spring.
102 The Augur Hole.
103 Lilliputian Hall.
104 Spade's Grotto.
105 Slippery Hill.
106 Hall of Ruins.
107 White Cloud Room.
108 Sentinel Office.
109 Bishop's Rostrum or Pulpit.
110 Journal Office.
111 Calypso's, or Island No. 2.
112 Cerulean Vault.
113 Rugged Pass.
114 Chapel.
115 Vestry.
116 Josephine's Arcade.
117 The Parsonage.
118 The Junction.
119 The Lone Chamber or Ball Room.
120 Dry Branch.
121 Island of Confusion, or No. 3.
122 Grand View Island, or No. 4.
123 Sandy Branch and Air Torrent.
124 Newhall's Forum.
125 Grosvenor's Avenue.
126 Gothic Chapel.
127 The Gallery.
128 Indian Footprints.
129 The Den.
130 Ship in the Stocks.
131 Crawfish Spring.
132 Maggie's Grotto.
133 Joseph's Pit.
134 Lama's Bower.
135 Marble Rivulet.
136 Marble Hall.
137 Miller's Reach.
138 Andrew's Retreat.
139 Rode Rock No. 2.
140 The Devil's Elbow.
141 The Pit.
142 Langsdale's Basin.
143 Wash. Rothrock's Island.
144 Bourbonoi.

THE OLD CAVE. We shall first describe that portion of the cave known previous to 1850, and at present called by the guides the "Old Cave." The mouth of the cave is twenty feet wide and six feet high; the roof arched, the floor of earth, with here and there a fallen slab of rock. For perhaps 100 feet* we descend gradually and enter a spacious corridor known as Faneuil Hall, forty feet wide, eighteen feet high, and probably 180 feet in length. Across the farther end of this hall a stone wall has been built, and a doorway constructed, and through this one passes into Twilight Hall, where the last rays of daylight disappear and the King of Darkness begins his reign. Stopping a few moments to accustom our eyesight to the changed conditions, we pass onward and soon enter the "Columbian Arch," an almost perfect semi-cylindrical tunnel, seventy-five feet in length. From this we emerge into "Washington Avenue," a grand passageway, 275 feet long, thirty feet wide and forty feet high. Near the farther end is "Falling Rock," a huge mass of limestone, resting partly on edge, 33x16x14½ feet in dimensions, and weighing, therefore, about 535 tons. Ages ago it fell from the roof and assumed its present position, one which earthquakes have failed to change, but which appears dangerous to the average visitor who passes beneath its towering form.

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*The proprietor of the cave, Mr. H. A. Rothrock, would not permit accurate measurements to be made, except of a few of the rooms. It is needless to say that the measurements as given in the previous geological reports have many of them been greatly exaggerated. The map of the cave accompanying this report is the same as was published in the report for 1878, it being impossible to make a new map without new measurements to verify the distances.

Within Washington Avenue a peculiar pungent odor became noticeable, and inquiry as to its source brought information from the guide that in 1884 certain gentlemen of Evansville attempted to corner the onion industry of southern Indiana by buying up all the onion sets produced that season. Wishing a suitable storehouse, they rented room in the cave and deposited therein several hundred barrels of the sets. But, however suitable the pure cave air is for the preservation of sweet potatoes and other mild edibles, it failed to act in like manner on the onions, and they soon began to sprout and grow. All were lost and were allowed to remain in the cave, their shriveled skins and pungent odor still reminding the visitor thereto of an attempted financial "corner," which failed to materialize. Another odor, more strong and disagreeable, especially in autumn and winter, is noted at this point or before. It is that of the exhalations of thousands of bats, which make the cave a winter-abiding place. Their faint squealing notes and flutter of wings are the only sounds that greet us from the depths of darkness beyond.

Passing under the "Falling Rock" and up a short declivity, we find ourselves in Banditti Hall, fifty feet wide, forty to fifty high, and partially filled with rugged fallen rock, grouped in great masses on either side of the pathway. Stepping from slab to slab, we pick our way, until finally the guide calls a halt and, lighting some "red fire," directs our attention to two outline figures formed on the ceiling above, by the scaling of the dark exterior from the whiter limestone. To one the name "Wyandotte Chief" was given many years ago by a correspondent of the Cincinnati *Times*, who wrote of it as follows: "We look up and see above the Falling Rock a mass of white limestone resembling the front of an Indian chief, with crown shorn to the scalp lock and fanciful ear-rings dangling from the ears. There he hangs, seemingly suspended, like Mahomet's coffin, keeping his dark and weary vigils, waiting to gloat over the death of some daring paleface, crushed by the Falling Rock below." Upon the other figure, which resembles the facial characters sometimes seen in Punch and Judy shows, the fanciful name of "Betsy and I Are Out" has been bestowed.

Banditti Hall is the closing portion of the common entry to both the Old and New caves. At its farther end the opening leading to the Old Cave is seen on the left, some twenty feet above the level of the floor, while about the same distance below, on our right, opens the doorway into "Fat Man's Misery" and the New Cave beyond.

Climbing a steep ascent into the Old Cave, we find ourselves at first in a passageway ten feet wide and seven feet high, with the floor of ochery clay a number of feet thick, the walls of oölitic limestone, and the roof here and there with the more soluble portions dissolved until it resembles a coarse-celled honeycomb in appearance. Passing onward beneath "Pigmy Dome," we enter "Continued Arch," a long passageway eight feet in height, ten feet wide, with an occasional crystal of selenite glistening on the dry and dusty floor. From this we pass into the "Canopy," a circular room, twenty feet in diameter and ten feet high, with a smooth white roof. This is succeeded by another long, low passage, where stooping is necessary for some distance, and then we pass down through a narrow passage into Lucifer's Gorge, forty feet deep, with precipitous, jagged rocks overhanging the sides. Up we climb once more, from rock to rock, and, reaching another opening, crawl over a natural bridge, and on hands and knees creep for seventy-five feet through the "Grecian Bend." Finally we emerge into Odd Fellows' Hall, one of the grand underground rooms for which Wyandotte is noted. This we measured carefully and found to be ninety feet wide, 210 feet long and sixty-five feet or more in height. The massive ledges of limestone forming the walls project toward the top, each layer a few inches farther than the one below, so that the ceiling is oval in shape, much narrower than the floor and appears to be hollowed out by successive fallings of rock. Great masses of fallen rock partially fill the room, and bats by tens of thousands hang head downward from the ceiling. We extinguished the lights, and their low squealing notes became instantly hushed, and the only sound which broke the death-like stillness was a continuous faint and lisping noise, like the ripple of water over a distant waterfall, due probably to the rustle of the wings of such as were flying through the Plutonian darkness.

On the right side and about fifty feet from the entrance to Odd Fellows' Hall is a pit hole or perpendicular cleft in the floor, through which an average sized man can just squeeze himself. This is the opening into Rothrock's Straits, a deep and narrow passageway which connects with the new cave in Rothrock's Cathedral.

From Odd Fellows' hall we climb by a rugged stairway and pass onward through narrow passages, and beside pits and chasms—the way ever seeming to grow rougher—the hills and valleys following each other in rapid succession. In one place we descend full fifty feet and from the bottom note on our right the perpendicular walls of rock known as the "Cliffs." Over these in ages past a drapery of stalactites has been thrown in graceful folds, resembling a cascade which in mid-air has been congealed into stone, and is most worthy of its name—"The Falls of Minnehaha." Below these overhanging cliffs is the gaping mouth of the "Pit"—a deep cavity leading by one drop fifty feet into space—as yet unexplored. From the foot of the "Cliffs" we make our way with difficulty up Uncle Sam's Stairway and then under the "Dead Fall," a large, flat rock which lies at an incline across the passage, the upper edge supported by less than three inches of a thin rock projecting from the wall. From the "Dead Fall" onward for a distance of perhaps 1,000 feet the way is a succession of steep climbs and steeper descents, varied by an occasional crawl on hands and knees; and a final twisting of the body into shapes innumerable in order to effect the passage of the "Screw Hole," which forms the portal to the "Senate Chamber," the final room of the Old Cave.

Collett describes* the Senate Chamber "as a vast elliptical amphitheater, estimated at six hundred feet long and one hundred and fifty feet wide. The sides are built up with massive ledges of limestone, thinning and converging upward into a monster dome, with a flat elliptical crown fifty by twenty feet in diameter. The center of this vast room is piled up with a great mass of rocky debris fallen from the immense cavity above."

Other than the dimensions, the above is an excellent description of the room. Exact measurements show the room to be 144 feet long and 56 feet in width. The mass of fallen rock in the center, known as "Capitol Hill," is about thirty-two feet in height and is crowned to a depth of several feet with an immense mass of stalagmitic material. From the center of this mass rises from the top of the hill the grandest natural wonder in Wyandotte Cave—the great fluted column of satin spar, or crystalline carbonate of lime, known as the "Pillar of the Constitution." Perfectly cylindrical, seventy-one feet in circumference, and extending from the crest of the hill to the ceiling above, this enormous column exceeds in magnitude any similar formation in any known cave on earth. From the point where it first became visible in the dim light of our candles it appeared "like an immense spectral-looking iceburg looming up before us, looking as if it had just arisen from the foaming waves of the ocean on a dark and foggy night." The entire column is composed of "satin spar"—a rather soft, white, striated mineral, the purest form of carbonate of lime. From one side, near the base of the column, has been removed by the Indians or some prehistoric race in ages past, several hundred cubic feet of this material. A full account of some interesting discoveries made here will be given farther on under the heading of "Former Visitors to Wyandotte Cave."

Down the sides of the "Pillar" tiny streams of water are constantly trickling, and, spreading out upon the top of the hill, quickly evaporate, leaving behind the solid particles to make thicker the crust of so-called "alabaster," which covers the rough edges of the mass of rocks. This will continue for thousands of years, until ultimately, by continued accretions, this hill will reach the ceiling and enclose entirely the wondrous pillar with its flutings and carvings, wrought in ages past by that magic graver—water.

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*Indiana Geol. Surv., 1878, 473.

Back of the "Pillar of the Constitution" is the "Chair of State"—another handsome mass of stalactites and stalagmites that extends from the top of the hill to the ceiling. Behind this on the right is the entrance to "Pluto's Ravine," the roof of which is studded with representations of sprigs, twining tendrils and branching corals, all wrought from calcite and "alabaster" in most exquisite fashion by the hand of nature. Many are broken, being the remains of those removed before 1850, when the cave and its contents were esteemed but lightly by the owner, and no care was taken to prevent its despoliation by visiting vandals. Beyond this point one can penetrate but a few yards in the "Old Cave," the roof and floor coming close together and barring farther progress.

Much diversity of opinion prevails as to the distance between the "Pillar of the Constitution" and the mouth of the cave. Stelle, in his work published in 1864, says it is "just three miles." Both Collett and Hovey place it at two miles. Flint, in 1833, before it was thought necessary to exaggerate the distance, gives it as one and a quarter miles. Pedometer measurements, made by Mr. Peddle, make it one and one-sixth miles, so that Flint's statement is probably not far out of the way. The rough character of the passage, the many steep ascents and corresponding declivities, added to the oppressive silence, cause persons unaccustomed to subterranean travels to think the distance much greater than it really is.*

SHORT ROUTE. As before noted, one must pass from the mouth of the cave to the end of Banditti Hall and there start on the Short Route through a narrow and slippery descending passage known as the "Scuttle" or "Fat Man's Misery." By sliding or crawling downward for about 15 feet, we find ourselves at the entrance of "Bat's Lodge," a low room 70 feet long, 21 feet wide and five to six feet high, the walls and roof begrimed with the smoke of fires kindled by former inhabitants, of which more anon; the floor a mixture of dry, dusty earth, with here and there a piece of fallen limestone. We have been gradually descending from the mouth of the cave to Bat's Lodge, and barometer measurements show the floor to be 150 feet lower than the Cave Hotel. Beyond this room the roof so closely approaches the floor that "Counterfeiter's Trench" was dug through the earthy deposit which had silted up the

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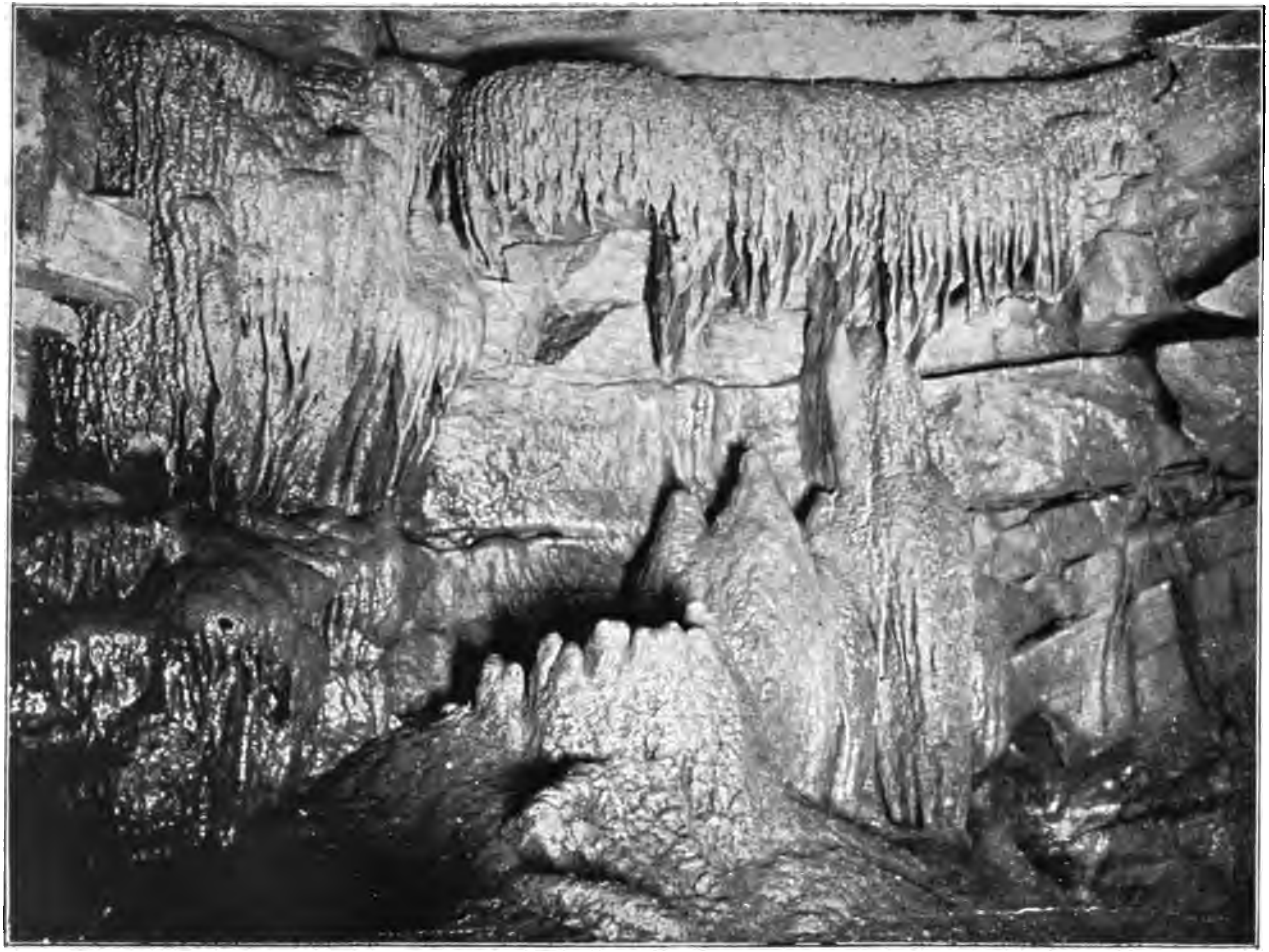
*The lengths of all the caves visited by our party were found to be much less than they were reported. Where the natives had explored for "miles underground," guessing the distance as they went, careful measurements proved their miles to be rods, or, at the best, furlongs. For example, Marengo Cave has been advertised far and near as containing seven miles of underground passages. Our measurements showed its total length to be 3,850 feet, or seven-tenths of *one* mile. Except the lengths of the passages in Wyandotte, Mr. Peddle made all measurements with a 50-foot tape, hence they can be relied upon as being exact.

way. Through this trench we easily pass and find ourselves at the foot of "Rugged Mountain," a mass of broken pieces of limestone, thirty feet or more high, which fills the greater part of a large room. Climbing this mountain we reach the "Rotunda" or upper portion of the room, 52 feet one way by 90 feet the other, with the roof 16 feet above the top of the mass of rock. Around the edges of the room are numerous deposits of fine, white, needle-shaped crystals of epsom salts (magnesium sulphate) encrusting the rocks and sparkling like frostwork in the light of our candles. They seem to exude from a porous matrix of magnesian limestone, and if not disturbed often attain a length of three to five inches. Passing down "Rugged Mountain" on the farther side we enter "Hanover Chapel," where numerous artificial piles of heavy stones, dedicated to some Greek fraternity or college class, stand as monuments to the muscular ability of visiting students in days gone by.

A short distance beyond this point we climb again and enter the "Coon's Council Chamber," a circular room 35 feet in diameter. Here two bands of blackish flint or jasper about four inches in thickness, first noted in descending Fat Man's Misery, are very prominent around the walls. A few yards farther on we come to "Delta Island," an uneroded mass of limestone, 50 feet long by 20 feet wide, on either side of which one may enter that part of the cave called the "South Branch," which forms the greater portion of the Short Route. To the left of Delta Island the passageway leads onward through "Rothrock's Cathedral" and the "Augur Hole" to the end of the "Long Route," described under another section.

Passing to the right we enter the "Dining Room," 40 feet wide, 10 feet high and 70 feet in length, the monotony of the limestone walls being relieved by several bands of jet black flint, about three feet apart. One of these bands has the flint in quadrangular blocks, while in the others it is in nodules, many of which are several inches in diameter. Sometimes these nodules resemble in form a geode, and when broken show a crystalline center, the siliceous particles having collected and crystallized about a common nucleus. Leaving the Dining Room we proceed through a short pass to the "Drawing Room," whose dimensions are about 25 x 10 x 60 feet, and from this into the "Junction Room." From here three passages diverge, one to the left through Creeping Avenue, one straight ahead to the right of the "Continent," the latter being a vast mass of uneroded limestone, around which the two branches of the old subterranean river formerly flowed, and the third, known as the "Cut Off," turning abruptly to the right and entering a short, tortuous, descending passage, which leads out into the main cave between Counterfeiters' Trench and Rugged Mountain.

Taking the passage past the right of the "Continent" we enter the "Council Chamber," a spacious room 15 x 50 x 100 feet, which, like



THRONE AND CANOPY, WYANDOTTE CAVE.

"Hanover Hall," contains many artificial monuments, erected in the past by enthusiastic visitors who knew no better way of proclaiming to the world the fact of their existence. Narrowing again, the main passage continues for perhaps 200 feet, when once more it expands into another of those grand subterranean rooms which characterize Wyandotte Cave. This has been dubbed the "Hall of Representatives," accurate measurements showing it to be 100 x 60 feet, with the ceiling 35 feet above those masses of fallen rock which in the past filled the space of the broad dome above. Where these large rooms occur, the old river which eroded the cave must have flowed over a softer portion of rock and eroded or dissolved a great basin in the bed or floor of the channel, perhaps escaping by an outlet now hidden. In time the roof, no longer self-supporting, came tumbling down and partially filled the basin. From most of the rooms, as from the Hall of Representatives, one must climb 20 or more feet to the mouth of the passage leading onward.

Beyond this hall we descend the "Hill of Science" into a lower portion of the cave, from which a low, wet side passage turns to the right. Here for the first time we encounter mud, and the floor of the "No. 10" passage, as it is called, is for the greater portion of the year covered to a depth of several inches with standing water. We next arrive at the junction room, called "Jordan's Wait," where that noted scientist, Dr. D. S. Jordan, once had several hours for cool reflection, having been left in total darkness by the accidental extinguishing of a candle which he had no means of relighting. This junction room is located at the foot of the "Continent," where the passage which turned to the left around that body, meets the one through which we have traveled.

Turning to the left, we enter the most southern arm of the cave, and, passing through a damp-floored passage, 150 feet long by thirty feet wide, we find ourselves at the foot of a slippery hill on top of which is one of the most handsome formations in the cave—the "Throne and Canopy." The former is composed of a circle of rounded stalagmites cemented together and having the general appearance of a throne of state, while at a distance of six feet above is a curtain of broad, leaf-like stalactites draped in a graceful semi-circle and attached to a projecting mass of crystalline limestone. From a crevice or seam between the massive layers forming the walls the water for ages has seeped, then evaporating, has produced these charming natural wonders, and giving a slippery coat of stalagmite to the surface of the hill below.

Beyond the throne is a long stretch of partly explored avenues and side branches, through which visitors are not often taken, there being therein but one scene of more than passing interest. This is "Helen's Dome," so named by that nestor of cave explorers, the Rev. H. C. Hovey, in honor of his wife. To reach it one must pass through "General Scott's Reception Room," seventy-five by 100 feet in dimensions, and then by stooping and crawling through a narrow passage into "Diamond Avenue," "where nature asserts her power to work miracles of beauty from cheap materials, transforming gypsum and epsom salts into lustrous crystals which sparkle on the walls and glisten from the floor." Leaving a branch to the right, we turn to the left, and passing cautiously beneath a poised mass of fallen rock, which seemed ready to fall at the slightest touch, we entered a large opening midway between roof and floor, and a few feet farther on found ourselves at the foot of a great circular pit some twenty feet in diameter and extending upward through the solid limestone for eighty feet or more.

This was Helen's Dome, and when the guide kindled his "red fire," and the light therefrom revealed the rugged, waterworn carvings of the sides, and the pendent stalactites which far above gleamed and glistened from their inaccessible heights, we with one accord voted it the wildest and most romantic bit of scenery which the cave possessed.

Retracing our steps to "Jordan's Wait," we take the right branch around the Continent. This leads us on through a low passage known as "Purgatory," 140 feet in length, its floor of yellow ochre, with here and there a handsome crystal of selenite, its roof of white limestone, with many fantastic grooves and carvings wrought in days of yore by the slow but powerful energy of flowing water.

Emerging from Purgatory we assume once more a standing posture, and find ourselves in "Caliope Bower," where many stalactites grace the walls and ceiling. From thence we pass into "Whispering Gallery," where the floor resounds to our tread and the low tones of our voices are echoed back and forth from the arched sides in a manner similar to that noted at the bottom of a deep and empty cistern. Then comes the "Palace of the Genii," where these gods of fable dwell beneath a roof spangled with glittering crystals of calcite and gypsum. The "Pillared Palace" follows, and therein is found a wealth and profusion of cave formations such as no words of man can properly picture. Pillars, stalagmites and stalactites abound of every conceivable form which the fancy can suggest. Many of the stalactites are no larger in diameter than a lead pencil and are curved and twisted in a unique and grotesque manner seen elsewhere in no Indiana cave. Prof. Collett says* that they "are pushed out of the solid rock and still growing by propulsion from the bottom," a statement which the average scientist of to-day will accept *cum grano salis*. The bent and twisted condition of the slender stalactites is doubtless due to the varying currents of air which pass through portions of the cave and force the tiny drops of water on the end of the stalactite first to one side and then to the other of the tip. The air of Wyandotte flows outward, or toward the mouth, in summer, and inward, or toward the depths of the cave, in winter. This difference in direction of flow can but have its influence on the formation of such slender stalactites as those above mentioned.

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*Geol. Surv. Ind., 1878, 476.

Emerging from the Pillared Palace by an ample doorway flanked by handsome pillars of calcite, we leave on our left a room where much quarrying of jasper was done by the ancient visitors to the cave, and pass onward to "Creeping Avenue," where the roof for a distance of 172 feet comes down to within two and one-half feet of the floor, and progress is possible only upon hands and knees. According to the guide, the dryness of this portion of the cave is slowly increasing and as a consequence epsom salts (magnesium sulphate) is becoming more abundant. Where the cave is damp with dripping water, stalactites and other forms of calcium carbonate are abundant; where the dripping has ceased but the walls still give off more or less dampness, calcium sulphate or gypsum is the prevailing formation, and where perfectly dry the epsom salts alone are being produced. The tiresome crawl through Creeping Avenue finished, we stand erect once more in the "Junction Room" at the head of the "Continent" and the exploration of the Short Route is at an end.

The estimated length of the portions passed through, based upon pedometer measurements, is as follows:

Fat Man's Misery to Delta Island	1,200 feet.
Delta Island via Creeping Avenue to Hovey's Point	2,400 feet.
Jordan's Wait via House of Representatives to end of "Cut Off"	2,000 feet.
Total	5,600 feet. 1.06 miles.

Long Route. In going through what is known as the "Long Route" in Wyandotte, we passed from the mouth of the cave to Delta Island over the same way as described above under the "Short Route." At Delta Island we turned to the left and traversed the "Sandy Plain," a passage about 350 feet long, twenty-five feet wide and six to ten feet high; the floor of which is covered in places to a depth of several feet with sand deposited by the ancient cave river. At the end of the "Plain" we found ourselves at the foot of the "Hill of Difficulty," which is but a mass of fallen rock, forming, as it were, a foot-hill to the grander ' Monument Mountain," which lies beyond. On the left, in climbing this hill, the guide pointed out the entrance into Rothrock's Straits, that narrow and deeper passage connecting the "Old" and "New" caves.

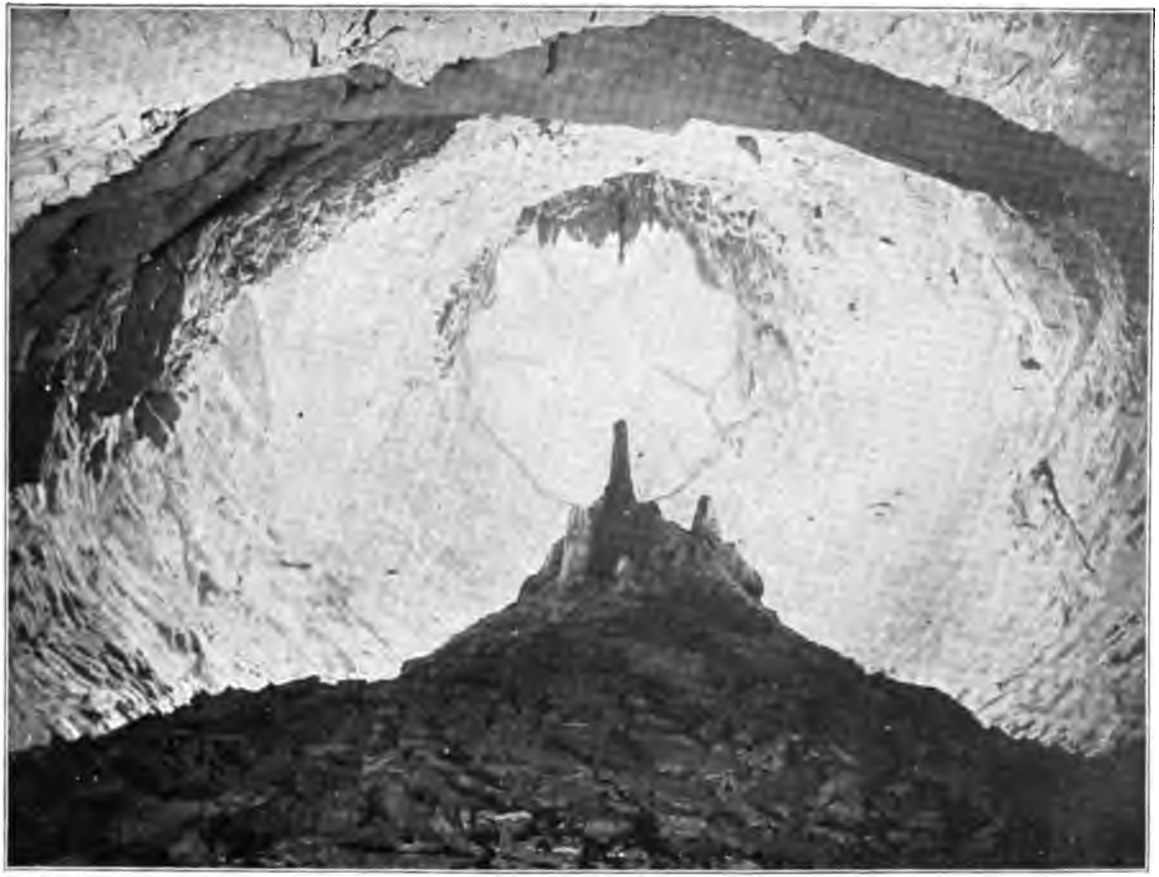
Reaching the top of the Hill of Difficulty, we found ourselves within the confines of the largest underground room yet known to man—"Rothrock's Grand Cathedral." Before us in the dim candle light was a towering mass of fallen rock, thrown together in most glorious confusion and piercing the gloom above us for 135 feet. Following the guide and clambering from rock to rock, we made the ascent by easy zigzags and reached a point near the summit with but little fatigue. The crest of "Monument Mountain," like that of "Capitol Hill," in the "Senate Chamber" of the Old Cave, is covered to a depth of several feet with an encrustation of stalagmitic material. This is slowly increasing in thickness by the accretion of solid particles of limestone left by the evaporation of the water which is constantly trickling in a small stream from the roof above. The uppermost ten or twelve feet of the mountain is very smooth and slippery, and one has much difficulty to keep his footing while climbing to the very pinnacle, from which projects a brownish-yellow stalagmite 6.5 feet in height and 3.7 feet in circumference. Below this a short distance, and on the opposite side of the "Mountain" from the entrance, is another stalagmite 6.8 feet in height by 5.2 feet in circumference, while but a short distance away is a third and shorter one. The last two are composed of spotless white, almost translucent limestone, and are known as "Lot's Wife and Daughter."

Forty or more feet above the crest of the mountain expands "Wallace's Grand Dome." The center piece of this is, in the words of Hovey, "a smooth, elliptical slab of oölitic marble 60 feet long by 30 wide, finely contrasting with the darker limestone, from which it is divided by a deep rim, fringed with long stalactites, curling like leaves of the acanthus."

Leaving three candles burning a few feet below the summit, we descended the opposite side, and, extinguishing our lights, as soon as the eye accustomed itself to the surroundings, beheld a scene as grand as human mind can fancy—"an indescribable vision, as if an opening had been made into the realms of supernal splendor." The scene is known as the "Cathedral by Moonlight," the faint candle light reflected from the white, oval dome appearing like a halo of moonlight over the dark crest of the mountain, while the three stalagmites stood like spectral visions surmounting the dark and rugged ledges which rose between us and the source of the faint light above.

Relighting our candles, we found a few feet farther on, the "Sulphur Spring," the trickling waters being caught in a shallow cavity of a round stalagmite. By the side of the spring is a smooth and slippery opening thirty inches wide by fifteen inches high. This is the famous "Augur Hole," which, when first discovered in 1850, and enlarged as before mentioned, admitted the explorers to a large area of unknown passages and rooms—yet none so grand as those already noted.

Through the Augur Hole we made our way, some head first, others the reverse, all finally landing safely about ten feet below in a low, damp room known as "Lilliputian Hall," along which, by stooping, we found our way into "Spades Grotto," once evidently connected with Rothrock's Cathedral by a passage now hidden by fallen rock. From thence, in divers manners, we descended Slippery Hill and found ourselves in the "Hall of Ruins," a passage 150 x 30 feet, with an average height of



ROTHROCK'S GRAND CATHEDRAL AND MONUMENT MOUNTAIN, WYANDOTTE CAVE.
(The circular space above is the center of the roof of the Cathedral.).

perhaps eighteen feet; then into "White Cloud Room," probably 350 feet in length, where the roof and walls are crusted with an efflorescence of gypsum, resembling after a fashion "billows of fleecy clouds." Beyond this room we passed through the "Journal Office," near the farther end of which is the Bishop's Rostrum, a high platform of rock, 8 x 10 feet in dimensions, from which portions of many a sophomoric oration, as well as several divine dissertations, have in the past been delivered. "Calypso's Island" is a large mass of uneroded limestone, on both sides of which the old cave stream has forced a passage. The floor of the passage to the left of the "Island" resounded our steps in a peculiar echoing fashion, suggesting the presence of a lower passage beneath our feet. The two wings of the main passage converge at the farther end of Calypso's Island and expand into the "Cerulean Vault," a room 40 feet wide by 20 feet high. This narrows into "Rugged Pass," from the side of which a narrow cleft in the rock leads by an ascending, very low and tortuous passage, known as "Worm Alley," into Milroy's Temple. This is a room 100 x 150 feet in dimensions, around the upper edge of which are found some of the most handsome formations in the cave. "One of them is a row of musical stalactites, broad and thin, on which a melody can be played by a skillful hand. There are also creamy stalactites, vermicular tubes strangely intertwined, convoluted roots, mural gardens and galleries, gay and grotesque." A deep pit, the bottom of which is sixty feet or more below the entrance, is found in one side of the room, and the sound of a stream of water falling from a cleft in the ceiling and splashing on the rocks at the bottom of the pit is a pleasing break of the monotonous silence of the vast rooms through which we have come.

Once more bowing our heads to the inevitable, we crawled, squirmed, rolled and pulled ourselves through "Worm Alley" back into the main cave. Following our guide, we passed on through Josephine's Arcade, where a silhouette of the "Cave Queen," formed by a falling away of the white gypsum from the darker limestone, greeted us from the wall. "Indiana University Chapel" and the "Ball Room" succeeded and brought us to the "Junction Room" of the Long Route. Here the cave forks, one branch leading to the southwest and the other continuing northward to "Crawfish Spring" and Wabash Avenue. Taking the latter, we found it to be made up of a succession of halls, galleries and avenues, each with its own fanciful name and pleasing peculiarities, yet no place worthy of more than passing notice when taken in contrast with the grand scenes already described.

Crawfish Spring itself is formed from a small stream which flows through a cleft in the rock, and from it a trickling rill meanders on beneath the edges of the jutting walls to be soon lost to view beneath the roof which a few rods farther on comes down to meet the floor. Above the spring is the passage known as "Wabash Avenue," which extends for several hundred yards in a northwesterly direction where it forks into a number of low and muddy branches.

Retracing our steps to the "Junction Room," we took the southwest passage, the first room entered being the "Frost King's Palace," eight feet high and twenty wide, where every object, great and small, is encrusted with sparkling crystals of gypsum. To one side is the "Bridal Chamber," and therein are found some of the finest of the gypsum rosettes for which the cave is noted. Several of these are four and a half inches in diameter, the slender crystals forming them having protruded from the pores in the magnesian limestone, and then, uniting into fibrous masses, have curved inward to form the *oulopholites*, or curl-leaved stones, each of which bears a close resemblance to a true rosette.

The "Ice House" is a rough-floored room where dripping water from the roof has covered the surface of the rocks with a film or coating of the thinnest and most translucent of calcite, resembling ice. Leaving the opening to the "Unexplored Region" on our left, we descended from the Ice Room into "Morton's Marble Hall," 1,100 feet in length, the sides and walls of which, in Collett's words, "are completely dressed in snowy whiteness, equaling the brightest marble halls of dreamland, song or story." Occasional nodules of jet-like flint are seen exposed along the walls and ceiling, and here and there are examples of the gypsum rosettes already mentioned. Beyond the "Marble Hall" is "Queen Mab's Marble Garden" and the "Fairy Palace," both of which have their walls covered with a gypsum efflorescence which has assumed the shape of flowers, leaves, sprigs and fanciful forms of many kinds. Beyond this end of Fairy Palace, 1,750 feet from the Ice House, are several low passages which visitors seldom enter, and from here we started on our return to the entrance of the cave.

The so-called "Unexplored Regions" opening from the Ice House and running north have been explored by guides, but visitors seldom pass within their portals. Washington Rothrock, the oldest and best known guide of the cave, has been through this portion several times as far as Rothrock's Island. The formations therein are said to be wondrously beautiful and more numerous than in many of the more thoroughly explored regions of the cave. A large series of specimens were obtained from some of these passages in 1893 for the World's Fair. A number of the larger passages of the Unexplored Region have not been penetrated as far as man can go, and some future explorer may, perhaps, find formations more beautiful and scenes more grand than those occurring in the better known portions of the cave.

The distance from Delta Island to Crawfish Spring, including Milroy's Temple, was estimated from pedometer measurements to be about one and four-tenths miles, and from the Junction Room to the end of Fairy Palace, about one-half mile.

The total length of the cave as traversed by the visitor who takes all three routes is, therefore, about as follows:*

Old Cave—from mouth to Senate Chamber	1.25 miles.
Short Route—from Fat Man's Misery, onward	1.06 miles.
Long Route—from Delta Island, onward	1.90 miles.
Total	4.21 miles.

ROTHROCK'S STRAITS. The writer and two of the guides passed through Rothrock's Straits in November, 1896. Dropping ourselves through the narrow cleft in Odd Fellows' Hall, we crawled down an angling passage over a mass of rough rocks and into a low room almost filled with fallen rocks. From this we crawled still farther down, climbing over great blocks of limestone and making our way beneath others partly loosened from the roof, until finally we reached the very bottom, probably seventy five feet below our starting point. Here we found another low room, with an earthen floor which had great cracks running through it in every direction, but with no signs that water had been present for centuries. From this a very low passage makes its way to near the Coons' Council Chamber, but there is no exit into that room. Retracing our way we took another route, and after much creeping, wriggling our way through dust, bumping our heads on the low ceiling, and with nothing in the way of interest to repay us for our trouble, we finally emerged on the side of the "Hill of Difficulty," and knew by experience that the Old Cave and the New are connected, and that the passageway between them is a very rocky road to travel.

EVIDENCES OF FORMER VISITORS TO WYANDOTTE CAVE. The first white men who visited Wyandotte Cave found evidences of its former inhabitancy by the Indians. Here and there throughout the Old Cave were pieces of hickory bark with their ends charred by fire—a sure sign of the previous visitations of man. Near the foot of one side of the great fluted "Pillar of the Constitution" was a large excavation, and scattered around the top and thrown over the sides of the hill which supports the pillar were many tons of debris quarried from the excavation. But little attention was paid to these features of the cave, and up to 1850 no record had been made of them.

The opening up of the New Cave furnished more plentiful evidence concerning these ancient visitors. The ceiling of Bat's Lodge, the small room first entered, was then black with smoke. Fragments of charred hickory bark strewed the floor, while moccasin tracks, now entirely obliterated, were plentiful. Hundreds of poles of sassafras, pawpaw, lin and other soft woods were found both in this room and in that portion of

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*These distances are for one way only. In taking the Short Route, one travels in addition the distance from the entrance to "Fat Man's Misery." If the Long Route is taken on a different day, one travels in addition the distance from the entrance to Delta Island.

Rothrock's Straits nearest the New Cave. None of these poles had been cut with a sharp instrument, but all had been twisted from the parent stem or hacked there-from with dull stone axes. On the left side of the room was found a sloping bank of earth and sand in which bark, sticks, leaves and bunches of twisted grass were plentiful. Digging into this bank in November, 1896, numerous pieces of bunch grass, the inside bark of lin or poplar trees and short stems of weeds were found. According to Mercer,* these were "remnants of a store of fuel resorted to when the torches waned or a relight was needed."

Near "Pillared Palace" is a room where strata of jasper nodules abound in the walls and where numerous chips and splinters of jasper are abundant on the floor. Rev. H. C. Hovey first called attention to the fact that the supposed "bear wallows" of this room are depressions where, in the treacherous light of bark torches, the ancient workmen reclined while they worked down to partial finish the desired blocks of jasper. Numerous fragments of charcoal and large heaps of chips of jasper are about each depression, but though careful search was made by Mr. Hovey, later by Mr. Mercer, and still later by myself, no partially finished article of jasper was found. The fragments are mostly oblong, with the faces parallel, their dimensions being on an average about 4x2x½ inches. Several quartzite bowlders have been found in the room, one of which is seen in the accompanying illustration to be lying on top of one of the pillars at the entrance of Pillared Palace.

The first explorers of the Long Route found in the passages beyond the "Junction Room" tracks of a small party of Indians who had wandered to and fro in that region. They had evidently entered by some as yet unknown opening, since the "Augur Hole," now the only means of entrance, was, when first discovered, entirely too small for the passage of a man. It is better, in my opinion, to consider that their means of entrance and exit has since been covered by fallen rock or, like that through "Fat Man's Misery," was hidden purposely by those ancient explorers, than to take the ground, as did Prof. Collett,† that the tracks were made 1,800 or 2,000 years ago, before the opening of the Augur Hole was so nearly closed as to prevent the passage of a man. These moccasin tracks were seen and noted by many of the early explorers, and low stone walls were put around them for protection, but the tracks have since been almost entirely obliterated by persons who, unmindful of the warnings of the guides, stepped over and upon them.

Up to 1877 it was generally supposed that the whites had made the excavation near the base of the Pillar of the Constitution in the Old Cave. Stelle, in 1864, wrote of it as follows:‡

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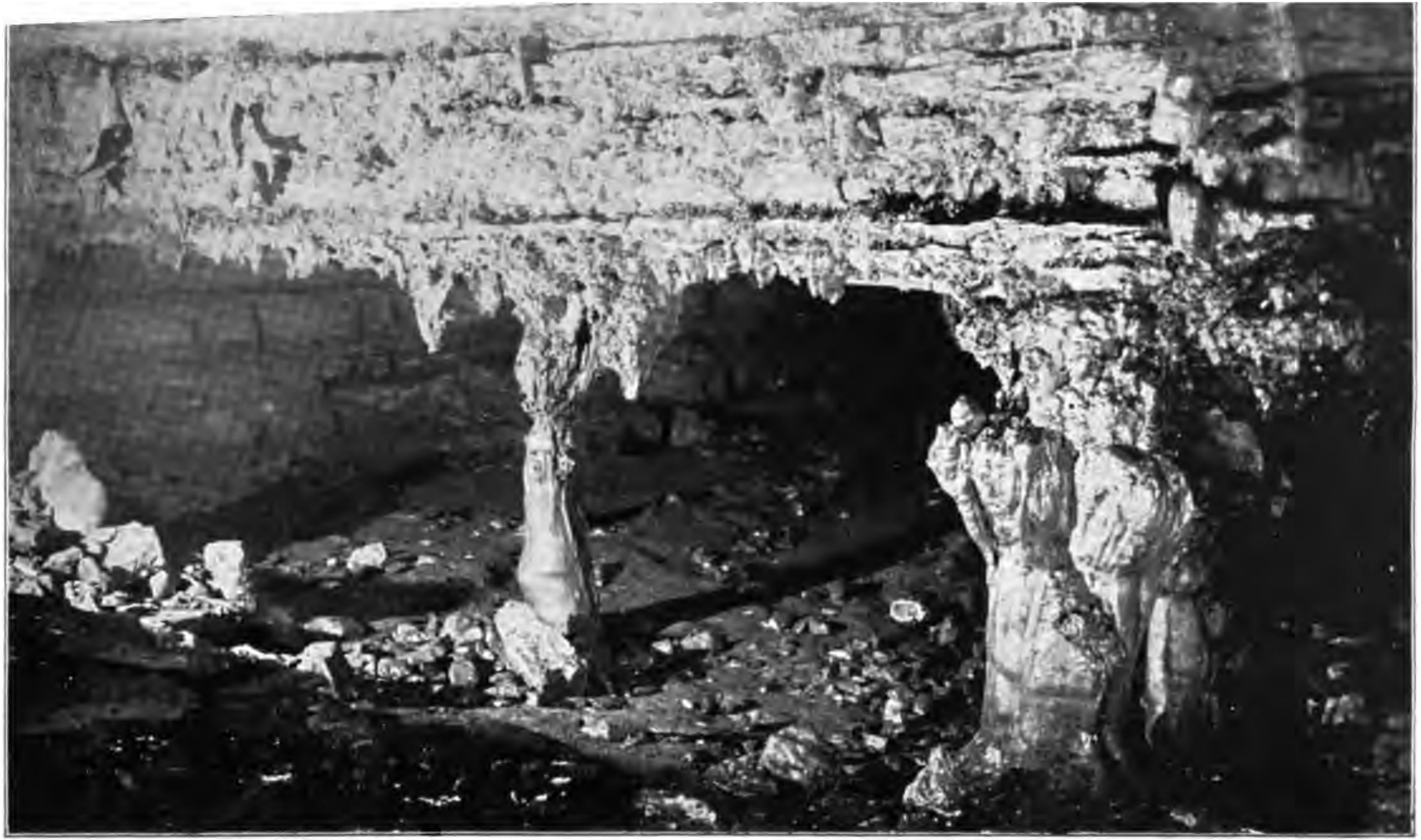
*Proc. Am. Phil. Soc., xxxiv, 1895, 400.

†Geol. Surv. Ind., 1878, 467.

Wyandotte Cave, 69-70.



ENTRANCE TO PILLARED PALACE, WYANDOTTE CAVE.

"For fifty years the people of a civilized—aye, a Christian nation, have visited the Senate Chamber, not as admirers of the great God who has reared for himself such a magnificent temple, but as vandals. All the most interesting formations within their reach have been broken up or carried away; and even the great pillar itself has not been exempt from their attack, for an excavation has been made in its side which must have required days of hard labor, and from which large quantities of the purest white stone have been taken and scattered over the floor of the cave."

Collett, in 1877, found three glacial bowlders in the Senate Chamber, which, "from indications, such as wear and bruises, had been used as hammers or grinding pestles, and proved conclusively that that part of the Old Cave had been visited, if not occupied, by men of the Stone Age." *

Rev. H. C. Hovey, in 1882, first claimed† that the excavation had been made by Indians "more than 1,000 years ago," and that the "round or oblong bowlders" of granite rock were the implements with which the ancient quarrymen wrought, being used "in breaking from this alabaster quarry blocks of a portable size and convenient shape."

H. C. Mercer, in 1894, visited the quarry, and mentions the finding of a pick made of stag's antlers, by Mr. Rothrock, and states that "the proof of Indian work at the spot was satisfactory and of a character never noticed and studied before the discovery of the site."‡

These constituted the recorded observations of the quarry when myself and party visited the place in July, 1896. It was noted at that time that the quantity of spalls and flakes of the material thrown over the side of the hill was very great, and that no digging had been done to discover the nature or thickness of the debris on top of the hill, nor to more fully verify the statement that it had been made by Indians. Our time being limited, no excavations were made at this visit, but on a subsequent one, in November, 1896, I secured the services of a workman and shovels and again visited the quarry. Careful measurements showed that above the debris a space eight feet long, six feet high, and five feet wide, or 240 cubic feet, had been quarried from the column. The top of the hill on which the column rests was found to be covered with an area 14 feet square of the debris, and through this, close alongside the base of the column, a trench was dug, eight feet long, three feet wide, and to the solid stalagmite beneath. It averaged four feet three inches in depth—*i.e.*, at that point the debris or pieces of quarried material and other matter was that thick. A perpendicular section through this trench disclosed the following:

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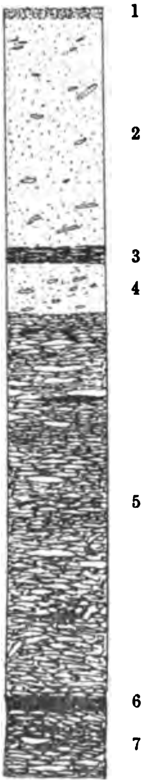
*Geol. Surv. Ind., 1878, 467.

†Celebrated American Caverns, 140.

‡Proc. Am. Phil. Soc., xxxiv., 399.



1.	Bats' dung	0.5 inch
2.	Ashes in a compressed, damp bed, with occasional flakes of stalagmite intermingled	14.0 inches
3.	Charcoal	1.0 inch
4.	Ashes, with flakes of rock	3.0 inches
5.	Rectangular flakes of stalagmite or satin-spar, varying in size from an inch or two square to pieces 8x3x1 inches, or even larger, with occasional traces of charcoal intermingled	28.0 inches
6.	Charcoal	0.5 inch
7.	Flakes of stalagmite	4.0 inches
	Total	51.0 inches

Six quartzose bowlders, weighing from three to six pounds, were found scattered through the mass which we threw aside, two of them within a few inches of the bottom. They were worn with use, and on the surface of two or three of them were depressions which appeared to be fingermarks due to excessive use. At any rate, they must have enabled the workman to retain the rock hammer more firmly in his grasp.

Remains of five different deer's horns, which mostly crumbled when disinterred, and numerous small bones, also too much decayed to identify to what animals they formerly belonged, were found at intervals in the trench.

By digging in a few other spots it was found that an area 14x14 feet, on top of this hill and at the base of the column, was covered to an average depth of three and one-half feet with the particles of stone quarried. In addition to this, no less than twenty tons of the material had been pitched over the hill. Much, if not all, of this additional space was formerly occupied by stalagmitic material, the base of the column flaring outward on this side, and when the space already mentioned as having been quarried *above* the debris is taken into consideration, there is little doubt but that more than 1,000 cubic feet of the stalagmite has been broken loose.

A large quantity of wood must have been necessary to have produced such a bed of ashes as was found. The carrying this in over the seventeen rough hills and through narrow passes, through which one has to crawl and where more than a candle is a burden to the ordinary visitor, must have entailed a vast amount of labor and leads one to suppose that the material sought was used for a purpose deemed especially valuable. What that purpose was, I have not yet been able to ascertain, there being few objects made of stalagmite among the "Indian relics" in any collection or museum in the United States.[*]

The deer's horns found in the debris were most probably used as wedges to pry loose the pieces of satin-spar after the latter had been cracked by the stone hammers. Such horns have been found in a number of caves of Europe, where ages ago they were put to similar use.[†]

The stalagmitic material on the summit of Monument Mountain in the New Cave was also quarried by these ancient visitors, but far less extensively than that in the Senate Chamber.

"Not inconsiderable must have been the danger of a long ramble in the cavern, when provided only with their primitive torches of hickory bark, and I can imagine that many precautions were taken in the way of shouted signals, of comrades left behind and of watches kept over a sort of reserve fire in 'Bat's Lodge,' when, venturing their lives on the chance of a rude firebrand that must never be allowed to go out, the red men quarried jasper and stalagmite in Wyandotte Cave."[‡]

Fauna. Taking into consideration the size of Wyandotte Cave, its fauna can not be said to be an extensive one. Since it contains no large streams or pools of water, blind fishes are not found therein, and the specimens accredited to it by Cope and other writers, were all secured from much smaller neighboring caves.

Three vertebrates inhabit the cave in greater or less numbers. Of these the most common is the little brown bat, *Vespertilio subulatus* Say. In the winter season it hibernates in the cave by myriads, finding its way into the most distant recesses. In the "Senate Chamber" of the Old Cave it was abundant in November, while on the same date several specimens were found beyond Crawfish Spring, more than two miles from the entrance.

A form of the "white-footed" mouse, *Hesperomys leucopus* Raf., similar to that taken in Marengo Cave, occurs in small numbers, a dead specimen having been taken in Rothrock's Straits. The cave salamander,

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[*] Since the above was in press I have received a letter from Dr. J. W. Powell, Director of the Bureau of American Ethnology, to whom samples of the material quarried were submitted, in which he says: "The specimen of stalagmite from Wyandotte Cave came duly to hand, and was submitted to an expert for chemical examination; this examination has been completed this morning, and indicates that the material is essentially pure carbonate of lime, the residue left on solution being too small for separate examination. It is of great interest to find that this cave deposit has apparently been worked extensively during prehistoric times. A few specimens of pipes, etc , carved out of white calcareous rock, presumptively stalagmite, are known, but there are not enough of these in the museums of eastern United States to indicate extensive quarrying of the material. It would be well to examine the collections of prehistoric material found in the vicinity of Wyandotte Cave with the view of ascertaining the extent to which the material was used locally by the aborigines. Researches in other districts demonstrate that, commonly, peculiar rocks available for primitive purposes were largely used locally, and that the use diminished in every direction from the natural center, finally leaving only a few sporadic examples, perhaps distributed to great distances."

[†] Mercer, *loc. cit.*

[‡] Mercer, *loc cit.*

Spelerpes maculicaudus (Cope), occurs in the first 150 feet, and is said to have been taken from the damp pit in Milroy's Temple; but careful search on both visits made thereto revealed no specimens. Several of the young of this or an allied species were found in the shallow muddy pools at the foot of the Throne in the Short Route.

Among insects, species of Diptera were rather plentiful. Two species of *Sciara* were secured, one in Creeping Avenue, the other near the Augur Hole, while three species of *Blepharoptera*, viz.: *defessa* O. S , *pubescens* Loew, and *specus* Aldrich were collected. *Phora nigriceps* Loew was found in numbers near the Augur Hole, and *Limosina tenebrarum* n. sp. was plentiful beneath loosely placed stones near "Fat Man's Misery."

Two species of Coleoptera, namely *Quedius spelæus* Horn and *Anopthalmus tenuis* Horn, both true cave forms, were taken, the former only near the Scuttle, beneath stones; the latter plentiful on top of Monument Mountain and near Crayfish Spring, and sparingly near the Throne.

A single moth, the only lepidopterous cave form taken, or hitherto recorded, was found in numbers between Banditti Hall and Monument Mountain, flitting close to the earth, usually about the borders of the rooms.

The cave cricket, *Ceuthophilus stygius* (Scudder), was common in the crevices of the ceiling and walls of the first room of the cave, and a single specimen, said to have been taken from the top of Monument Mountain, was presented to me by one of the guides.

The Thysanuran, *Degeeria cavernarum* Pack., was very plentiful in damp places on the floor, especially where any organic matter was present; while the cave myriapod, *Pseudotremia cavernarum* Cope, swarmed over the moist summits of Capitol Hill and Monument Mountain, and was frequent in several other localities.

Belonging to the Arachnida six forms were taken, the most common of which was the cave harvestman, *Scotolemon flavescens* (Cope). The others were *Phanetta subterranea* (Em.), and *Meta menardi* Latr., both true cave spiders: *Chthonius packardi* Hag., a semi-blind pseudo-scorpion, occurring in small numbers on the sides of Monument Mountain and in Odd Fellows Hall, and two undetermined species of acarina or mites; one of which occurs on the wings of bats, both living and dead, and was undoubtedly introduced into the cave by those mammals.

Three species of crustaceans were taken in the cave, namely, the blind crayfish, *Cambarus pellucidus* (Tellk.), found sparingly in Crawfish Spring but not noted elsewhere; and *Crangonyx packardii* Smith, and *Cæcidotæa stygia* Packard, both found in "Crawfish Spring" and in the rill running there-from, and also in the shallow pools at the foot of the "Throne" as well as in the "Pool of Deception" near its side. Specimens of a long, slender, whitish worm were also secured from the shallow pools at the foot of the "Throne."

Omitting the bat and mouse as not being cave residents, we place the list of animals taken by our party alongside of that listed by Cope from Wyandotte Cave in the Indiana Geological Report, 1872, 160, and find them to be as follows:

	BLATCHLEY, 1896.		COPE, 1872.
	VERTEBRATA.[*]		
1.	*Spelerpes maculicaudus* (Cope.)		
	INSECTA.		
2.	*Anophthalmus tenuis* Horn.	1.	*Anophthalmus tenuis* Horn.
		2.	" *eremita* Horn.
3.	*Quedius spelæus* Horn.	3.	*Quedius spelæus* Horn.
		4.	*Lesteva sp. nov.* Horn.
4.	*Ceuthophilus stygius* (Scudder).	5.	*Raphidophora.*
5.	*Phora nigriceps* Loew.	6.	*Phora.*
6.	*Blepharoptera defessa* O. S.	7.	*Tipulid.*
7.	" *pubescens* Loew.	8.	*Anthomyia.*
8.	" *specus sp. nov.*	9.	*Machilis.*
9.	*Sciara sp.* ?		
10.	*Sciara sp.* ?		
11.	*Limosina tenebrarum sp. nov.*		
12.	*Degeeria cavernarum* Pack.	10.	*Campodea.*
13.	*Blabophanes ferruginella* Hbn.		
	MYRIAPODA.		
14.	*Pseudotremia cavernarum* Cope.	11.	*Spirostrephon cavernarum* Cope.
	ARACHNIDA.		
15.	*Scotolemon flavescens* (Cope).	12.	*Erebomaster flavescens* Cope.
16.	*Phanetta subterranea* (Em).		
17.	*Meta menardi* Latr.	13.	*Anthrobia.*
18.	*Cthonius packardi* Hag.		
19.	*Diplotaspis sp* ?		
	CRUSTACEA.[†]		
20.	*Cambarus pellucidus* (Tellk.).	14.	*Orconectes inermis* Cope.
21.	*Cæcidotæa stygia* Pack.		
22.	*Crangonyx packardii* Smith.		

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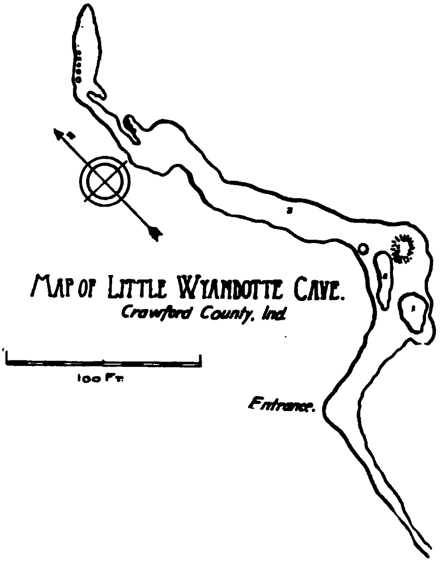
[*] Cope listed the blind fish from Wyandotte when in reality it was taken in Sibert's Well Cave, where I also secured a specimen. I therefore omit it from both lists.

[†] Cope listed among his Wyandotte crustaceans two additional species from neighboring caves, viz.: *Cæcidotæa microcephala* Cope, a synonym of *C. stygia* Pack., from Salt Petre Cave; and *Cauloxenus stygius* Cope, a unique form, of which he took in "Sibert's Well Cave," a single specimen from the lip of a blind fish on which it is parasitic.

LITTLE WYANDOTTE CAVE.

The entrance to this cave is situated at the bottom of a sink hole about 300 yards from the front of Wyandotte Cave Hotel. The floor of the cave is about 20 feet below the bottom of the sink, and descent is made by a ladder placed in a well-shaped opening about three feet in diameter. At the bottom one finds himself in an entry which leads both to the right and the left. The right hand passage can be followed only about 75 feet, when it becomes too small for farther progress. It contains no feature of interest except a few stalactites.



The left-hand passage was found by actual measurement to be 340 feet in length. Passing "Pompey's Pillar," a large stalagmite, the first room entered was "Cleopatra's Palace," where there are hundreds of fine stalactites, which show grandly in the glare of the magnesium light.

Beyond this room two pits, said to be 60 feet in depth, shut off the further side of the cave. A narrow partition of slippery stone separates the two, and serves as a bridge to cross the chasm. On leaving this natural bridge, we made our way along the side of a steep ledge that skirts the left-hand pit, and then passed around a gigantic fallen stalactite, which has been kept from rolling into the pit only by a friendly stalagmite against which it rests. Climbing a steep slope in which notches have been cut to serve as footholds, we enter a gallery, one side of the expanding mouth of which serves as a balcony above and partially around the deepest pit. On and above this balcony is a collection of cave formations of exceeding beauty and grandeur. A stately, fluted pillar, with its base expanding in broad-leaved masses of dripstone, thus forming a heavy folded curtain along the edge of the pit, is the giant of the group; while most unique of all is the "Corinthian Column," 10 feet high and less than three inches in diameter—a slender shaft of translucent snow-white satin-spar reaching from floor to ceiling. A number of fragile, tubular stems were clustered about the head of this pillar, each with a terminal drop of water, which glistened like a well-cut diamond in the light of our candles. Entering the gallery, in the words of Rev. Hovey:

"We wander on beneath a ceiling fretted with glistening pendants, amid pillars and pilasters, flying buttresses and interlacing arches, with here a cascade in mid-air transmuted into stone, and there a sculptured cell amid clustered columns." The cave finally ends in "Peri's Prison," where a narrow side gallery is separated from the main passage by a row of slender pillars, each but a few inches from its neighbor. All in all, Little Wyandotte is well worthy of visitation, and all those who wish to see the beautiful and at the same time experience a sense of the perils attending cave exploration should enter its bounds, cross the narrow bridge between the yawning chasms, and climb the slippery hill to the lovely gallery beyond.

FAUNA. Cave salamanders were plentiful in crevices about the walls of the descending shaft, and the cave cricket, *Ceuthophilus stygius* (Scudd.), was also taken in numbers in the same place. Other than these, no living forms were found except two myriapods, *Pseudotremia cavernarum* Cope. and *Scytonotus granulatus* (Say.), the latter an above-ground species, probably an accidental visitor to the cave.

SALTPETRE CAVE,

Crawford County, is located about one-third of a mile northwest from the mouth of Wyandotte Cave. The entrance, in a side of a ravine, is five feet high and 19 feet wide. Once within, a gigantic room expands, 220 feet long, 75 feet wide and 10 to 30 feet in height, with smooth, flat ceiling and earthen floor, the latter descending, and with its edges much encumbered with fallen rock.

Fragments of troughs, hoppers, vats and furnaces are still to be found, both in the cave and about its mouth, the sole remains of the saltpetre industry, carried on by Dr. Adams in 1812–15, an industry from whence the name of the cave was derived.

The one room comprises the cave, the only extension being a short passage in the right-hand corner of its farther end, where two openings extend upward through the ledges of limestone for 40 feet or more. A few stalactites occur about the edges of the ceiling, and in an alcove of the right wall, 50 feet from the entrance, are two columnar stalactites, six feet long and 20 inches in diameter, which have united from the center downwards, causing them to be dubbed with the fanciful name of "Siamese Twins."

FAUNA. The fauna of this large semi-subterranean chamber proved most interesting.

Bats by thousands were found therein in November, hanging head downward from the more remote and darker portions of the ceiling. Several specimens of the cave salamander were found in crevices near the mouth, while from similar localities were captured, in July, 50 or more extra large adult specimens of the cave cricket. In November but one or two half grown examples of the same insect could be found.

Three species of Diptera were taken from the walls, namely: *Sciara sp.*, *Psychoda minuta* Banks and *Blepharoptera pubescens* Loew, Two species of spiders, *Meta menardi* Latr., and a new form, *Tegenaria cavicola*, described by Banks in a supplemental paper, were taken from the ceiling, about 100 feet from the entrance. The harvestman, *Liobunum longipes* Weed., was also rather plentiful about the same distance.

That handsome autumn-emerging moth, *Scoliopteryx libatrix*, also evidently uses the cave as a winter abiding place, several specimens having been taken, November 5, from an alcove about 75 feet from the mouth.

In a wooden trough at the farther end of the room, used by the ancient "petre" workers to catch the drippings from a crevice in the roof, two crustaceans were secured, viz.: *Cæcidotæa stygia* Packard* and *Crangonyx vitreus* (Cope), the latter not having been previously noted north of Mammoth Cave.

SIBERT'S WELL CAVE.

This cave is located at the foot of the ridge traversed in going from the Cave Hotel to Little Wyandotte Cave, and is distant about 200 yards from the mouth of the latter. To enter the cave one must climb down the stone walls of a well about 20 feet, when he will find himself close to the bed of a stream which flows rapidly to the southward towards Blue River.

On the right, or down stream, one can crawl but a few feet. Up stream, by crawling, stooping and wading, one can make his way for about 150 feet. With the exception of the animals which inhabit it, there is nothing of interest in the cave, it being merely a low, waterworn subterranean channel which is doubtless constantly but slowly increasing in size.

FAUNA. A single specimen of the blind fish, *Amblyopsis spelæus* De Kay, was taken from a deep pool near the center of this cave. Cope secured his specimens accredited to Wyandotte Cave from this pool, and Collett also records† the capture of a specimen here.

The cave salamander, *Spelerpes maculicaudus* (Cope), was found to be very plentiful close to the mouth of the cave, in May, 1895, and in July, 1896, more than a dozen being taken on each date. The cave cricket, *Ceuthophilus stygius*, was also taken on both occasions, being found in numbers within fifty feet of the bottom of the entrance. The blind crayfish, *Cambarus pellucidus* (Tellk.), occurs sparingly in the water, and a single specimen of the small, brown, eyeless beetle, *Anophthalmus tenuis* Horn,

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*It was from this trough that Cope secured his specimens of *C. microcephala*, now regarded as identical with *C. stygia*.

†Ind. Geol. Surv., 1872, 153.

was taken from the damp floor over which it was crawling rapidly. Collett, *loc. cit*, records a similar beetle from this cave, and also the taking of a specimen of the blob, or "Miller's Thumb," a seeing fish, from a ripple in the stream.

EVASTON'S CAVE

is located about one and one-half miles northeast of Wyandotte, the entrance being at the bottom of a large sink hole. By crawling through a small opening and down a shelving slope of rock, we reached a water channel about three feet wide and eight to 20 feet high. We followed this up for probably 500 feet until it became too narrow for farther passage.

The stream which has eroded the channel is much smaller than that in "Sibert's Well Cave," and contains no deep pools. The cave was devoid of stalactites or other formations of interest.

FAUNA. No vertebrates, except a single bat which went flitting here and there before us, were noted. Two blind crayfish and several specimens of that small and common cave crustacean, *Caecidotæa stygia* Pack., were secured. The only other living form seen was an above ground myriapod, *Polyzonium rosalbum* (Cope), which was found beneath a loose stone about 50 feet from the entrance.

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Other caves there are in southern Indiana which we would gladly have explored and described had our time permitted. No two in the State are alike. Each is noted for some peculiar formation, room or passage which it possesses. In each and all can one see the results of the action of water—that greatest of nature's solvents and abraders, soft to the touch, gentle to look upon, its work of a day, a year, a century upon the solid limestone not appreciable to the eye—yet, by slow, unceasing action through the eons which have elapsed since that work began, it has carved every room and passage, constructed every pillar and stalagmite existing beneath the surface of southern Indiana.

THE FAUNA OF INDIANA CAVES.

BY W. S. BLATCHLEY.

In these days, when the great problem of evolution with its attendant factors of variation, adaptation, and distribution of species is foremost in the minds of all true scientists, the fauna of any region which is possessed of some peculiarity of climate, surface or other environment, becomes of especial interest. The total darkness and absolute silence which ever pervade the subterranean rooms and passages of caves have, in the course of centuries, proven potent factors in modifying the organs of those animals which by accident have taken up their abode therein. Caves have, therefore, given rise to many so-called species which to the evolutionist are but links forged in the chain of evidence tending to prove the truth of the great doctrine which he espouses. Any facts relating to the habits, life history or distribution of cave animals are, therefore, of more or less value and inasmuch as several short papers have been prepared by specialists to whom the different groups of Insecta and Crustacea collected in Indiana caves were referred, it has been thought best to bring those papers together into one supplemental chapter under the above heading. To these papers have been added such notes concerning the abundance, distribution and habits of the different forms as were recorded by myself or assistants.

VERTEBRATA.

MAMMALIA (The Mammals).

By referring to the preceding notes on the fauna of individual caves it will be seen that a number of above-ground mammals resort to caves either for shelter or in search of food. Foxes, minks, weasels, raccoons, cats, bats and mice were the ones noted by our party, either as present in the caves, or by abundant "sign" to be frequent visitors thereto. Of these, the bats and mice are the only forms which spend much time in the caves, and therefore they are the only ones whose organs have become appreciably modified by subterranean life.

Foxes, *Vulpes vulpes* (L) and *Urocyon cinereo-argentatus* (Schreber), resort to caves probably only for shelter, their dens and characteristic odor being noted in a number of the caves visited, usually within a few hundred feet of the mouth, but in Wyandotte back as far as Odd Fellows' Hall, a half a mile or more from the entrance.

The raccoon, *Procyon lotor* (L.), and the mink, *Putorius vison* (Schreber), frequent, for the most part, those caves which have streams flowing through them, and undoubtedly are on the search for crayfish and other aquatic forms which they are accustomed to find in their night prowlings along the margins of surface streams. But one or two of the caves entered did not show signs of "coons," and the tracks of minks were seen in five or six.

Cats (*Felis domesticus* Schreber) and probably weasels, *Putorius erminea* (L.), frequent the caves in search of the mice and bats which are found therein. In Wyandotte Cave especially, do cats abound, their tracks and excrement being very common in the Old Cave as far as Odd Fellows' Hall, and in the New Cave to Monument Mountain. According to Mr. Rothrock a number of cats have taken up their abode in the cave, and bring forth and rear their young therein. They have exterminated the "rats" (*Neotoma*) mentioned by Cope and Packard as being inhabitants of the cave, and probably also any mice that may have formerly occurred in the cave. They now subsist wholly on the bats, and are said to have become so skilled in the capture of these flying mammals, that they leap as high as eight feet into the air for them and rarely miss bringing them down. Near the "Scuttle," at the time of our visits, were many remains of the wings and feet of bats, the cats having stationed themselves there and caught "on the fly," as it were, the bats, while the latter were winging their way through the narrow passage.

In the early part of the present century the Black or Cinnamon Bear (*Ursus americanus* Pallas) was a frequent resident of southern Indiana. Their "wallows" and claw marks are plainly visible in Eller's and Salt Petre caves, Monroe County, and Connely's Cave, Lawrence County. The first named cave was probably the seat of the sanguinary struggle described in the following letter which was received from Mr. R. M. Hazelett, an old and honored resident of Greencastle, Putnam County. From this letter one can learn something of the methods of cave exploration among the early settlers, as well as some of the dangers incident thereto.

GREENCASTLE, IND., July 16, 1896.

Prof. W. S. Blatchley, Indianapolis, Ind.:

DEAR SIR—I see from the papers that you, in company with other scientists, are contemplating making a trip of exploration to the caves of southern Indiana.

I feel interested in the exploration and description of a cave about five miles southwest of Bloomington, Monroe County, and have often thought I would at some time visit it, but I am now too old. My reasons for feeling anxious to see or have a correct description of the cave are these: There was quite an exciting circumstance took place in that cave in which my father, Samuel Hazelett, was a party. My father, in 1818, moved from Jackson County and settled in Monroe County, where I was born October 2, 1819, nearly seventy-seven years ago. In those days most men hunted and killed wild game more or less, and some were called "hunters" from the fact that they did little else but hunt for a living. One of these was James Wood. He could not write his own name but preached and hunted. He was out hunting one day when there was a "skift" of snow on the ground and he struck the trail of a bear which he followed to this cave. He thought he would not be beaten, so he went and got my father, who was rather more a farmer than a hunter, and William Smith and Henry Wood, who were considered hunters. They all resolved to go into the cave after the bear, and prepared themselves by taking their guns, shot pouches, butcher knives, and flints and steels to make fire. They made also two sluts about as big and long as a man's arm. I reckon you don't know what a slut is. It is made by taking a large wick of some kind of cotton goods and squeezing tallow around the wick until the desired size is obtained. Then they started for the cave, and lit one of the sluts when they started in After going in some distance they came to where the cave divided, one passage going to the left and the other to the right. There they lighted the other slut and placed it on the dividing point so that if they should get lost and get back there they would know where they were. They then took one of the passages, and after traveling some distance they came to quite a room with high ceiling and the floor about six feet lower than the passage. They went in on shelving rocks projecting over the floor around the outside edges of the room. These rocks allowed a man to squeeze around on about a level with the entrance without going down on the floor. They finally spied a bear at the opposite side of the room lying under these shelving rocks. My father took the slut and crawled around on these shelving rocks until he got over the bear so as to give James Wood a good chance to draw a bead on the bear. As Wood was considered the best hunter he did the shooting. At the crack of the gun the concussion knocked the light out, and there they were with a wounded bear in darkness they could almost feel. They had to grope their way back to where they had left their other slut burning. Father was the hindmost one getting back. He afterward said he felt like the bear was just behind him all the way.

After consulting for awhile, they concluded best not to go back into the cave where there was a wounded bear, so they took the other branch of the cave, and after traveling some distance they came to another room somewhat similar to the first one, only larger. They got down on the floor of this, and after getting pretty well across it they discovered another bear. He sneaked around as though he wanted to avoid trouble, but that did not meet the hunters' views, so Wood fired on him and wounded him just enough to enrage him. He came tearing at them, and they all broke for the outlet. Henry Wood stepped into a hole and fell down. The bear ran over him, and as he did so gathered up Wood's gun in his mouth and slashed it around as if he would break it to pieces. Henry Wood cried out, for God's sake, not to leave him. With that, father stopped and stayed with him. He said he would not have left him then if the bear had eaten them both up. James Wood and Smith both got up on the declivity, and as the bear made a rush to get out Wood gave him another fire that turned him, and as he came back father fired on him and that turned him. Thus they kept him going back and forth, Smith loading for Wood and H. Wood loading for father, until the bear's head was in a jelly; but he had gotten too mad to die. Finally H. Wood got a chance to get out and left father alone, and he got back and laid down and crept under the ledge of rock as far as he could, pretending to be dead as much as possible, as he had always heard that a bear would not disturb a dead man. The bear came and put his nose to the back of father's neck and opened his mouth and let about a quart of blood run down his neck. He said he thought then that his turn had come, but the bear laid down against him without further molestation, only breathing his stinking breath where father had to breathe it. Hostilities had to cease until the bear saw proper to get up, which he did when he got ready. Then they soon dispatched him. His head was shot into a jelly. They skinned and quartered him, each one taking a quarter, and left the cave forever. They built up a fire and watched till day for the other bear to come out, but when day came they found by the tracks in the snow that he had come out and left. They then went to a neighbor who kept a pack of dogs, and got them and put them on the trail of the bear. They tracked him but a few miles until they found the bear dead, so they got them both.

I have never heard of the cave being further explored. The knowledge of it in the neighborhood may be very limited, as father moved from there to this place in 1824, and I suppose all the old settlers are dead or moved away.

Yours truly,

R. M. HAZELETT.

We next take up those species of mammals which were found to spend most of their lives in caves—namely, the mice and bats.

Family MURIDÆ (The Mice).

PEROMYSCUS LEUCOPUS (Raf.) White-footed Mouse. A form of this common above ground mammal inhabits Marengo Cave and, possibly, several other caves, where mouse tracks and excrement were plentiful. Three were captured at Marengo, within 400 feet from the entrance, in cyclone traps set for the purpose. They differed much in appearance from above-ground specimens, having larger external ears (13 mm. long by 11 mm. broad), longer whiskers (38 mm.) and more protruding eyes. Dr. C. H. Merriam, to whom specimens were sent, did not, however, consider these variations definite enough to separate the form, even as a distinct variety. The mice have been noted ever since the cave was discovered, but seem to keep close to the entrance, through which, however, no light passes. In the winter season they are very destructive to sweet potatoes and pumpkins stored in the cave, and at other seasons evidently subsist upon the tallow drippings and other refuse matters left by the visitors.

One mummified specimen, which had evidently been dead a number of years, was obtained in Rothrock's Straits, Wyandotte Cave. A dozen traps were set for five nights in this cave, but none of them were molested.

Family VESPERTILIONIDÆ (The Bats).

VESPERTILIO SUBULATUS Say. Little Brown Bat. This, the most common bat inhabiting Indiana, was found in small numbers in almost every cave visited. In the winter season they are said to be much more abundant, flocking by thousands to the caves for shelter, and there passing the winter, hanging head downward and in a state of comparative torpor, for months in succession.

A second visit to Wyandotte in November gave a better idea of the immense numbers which hibernate in that cave. As one passed along through the rooms and passages, their low squealing notes could be heard on every side, being the only sound which broke the death-like stillness. This squealing note was uttered only as we passed along, the light from the candles evidently disturbing those which had not yet entered their winter torpid state. Two other sounds they seemed capable of making, one, the cry of a single bat in rapid, broken notes, resembling the song of a robin in a minor key; the other, a noise somewhat similar to the short, quick alarm note made by the common ground squirrel, *Tamias striatus* (L.), when it espies some intruder on its domain.

The bats choose as a resting place that part of the roof where small portions have begun to flake, giving a certain degree of roughness, or small crevices, to which they can cling. They can not attach their claws to a smooth surface, hence from large portions of the roof of a room they may be entirely absent. In places where they find a suitable foothold they congregate so closely together that it is difficult to pull one from the midst of a group. On a low ceiling in Salt Peter Cave, Crawford County, an area, one foot wide by one and seven-tenths feet long, was measured, and the bats thereon were pulled off one by one and counted. Their number was 401 on the one and seven-tenths square feet.

When pulled or knocked loose from the roof they fall to the floor, where they lie motionless for some time, and then begin to flutter and crawl about, finally becoming lively enough to fly and find a new resting place.

They show a remarkable sense of direction in their flight, passing, in a darkness so profound that man can see absolutely nothing, swiftly and unerringly through openings but a foot or two in diameter, without hitting the walls. The direction of flight seems to be, however, one of instinct or training rather than of reason, since when a door was first put in the opening at the end of the "Scuttle," through which they had been wont to pass in numbers, they flew blindly against it and were killed by thousands.

The odor which the bats give off is a disagreeable one. At Wyandotte in summer it is not noticeable since their numbers are then few. In winter it is recognized immediately one passes into the main portion of the cave. Here, as elsewhere, the bats pass in numbers into the deepest recesses, being found abundantly in the Senate Chamber and sparingly near Crawfish Spring, two miles or more from the entrance. Several questions of interest, which to my mind are unanswered, arise regarding the cave life of these animals:

First. In a cave where the temperature is 54° F. the year round, how do they determine when warm weather has begun out of doors?

Second. How do those which spend the days of the summer season in the cave determine the approach of dusk?

Third. How do they distinguish in the intense darkness those portions of the roof which are smooth from those which are rough enough to furnish a foothold?

As is well known, bats are crepuscular in habit. They spend the day in darkness and the night in search of food. Such habits have, in the course of ages, rendered their eyes exceedingly small, their external ears large, their flight, like that of owls and whippoorwills, noiseless. Mr. Rothrock reports an occasional albino bat among the thousands hibernating in Wyandotte Cave; and also a larger, reddish brown species, probably *Atalapha noveboracensis* (Erx.), as being occasionally seen.

BATRACHIA (The Frogs and Salamanders.)

Family PLETHODONTIDÆ.

SPELERPES MACULICAUDUS, (Cope.) Cave Salamander.
Gyrinophilus maculicaudus Cope. Am. Nat., XXIV, 1890, 967.
Butler, Journ. Cin. Soc. Nat. Hist., XIV, 1892, 170.
Spelerpes maculicaudus, Hay, Am. Nat., XXV, 1891, 1133.
Id., Indiana, Geol. and Nat. Hist., XVII, 1891, 447.

This handsome salamander, which was described from specimens taken from springs at Brookville, Indiana, was found to occur in the following caves: Porter's, Donnehue's, Donnelson's, Clifty, Marengo, Salt Petre, Little Wyandotte, Wyandotte and Sibert's. It will doubtless be found in all others which contain streams of water or damp rooms near the entrance. It has also been taken by myself in a sandstone cave at Indian Springs, Martin County, and by W. P. Hay at May's Cave, Monroe County, and Kern's Cave, Lawrence County.

It is usually found within 150 feet of the entrance, clinging to the walls, especially in crevices and crannies just above flowing streams or pools of water. In Wyandotte it is said by the guides to be found occasionally in Milroy's Temple, one and a half miles from the entrance. If so, it must come down through a crevice in the roof. At Sibert's Well Cave it was abundant both in May, 1895, and July, 1896, as many as 20 specimens having been secured on each visit.

While its eyes appear as large and normal as those of allied terrestrial species, its sense of sight seems to be limited. It remains quiet when discovered and shows little fear until touched, when it scrambles deeper into the crevice or beneath some fallen rock on the floor. Even when a candle is put within a few inches of its head it does not move until it feels the heat.

The body of *maculicaudus* is somewhat stouter than that of *longicaudus* (Green). The tail of the former, while of about the same proportional length, is less wide and less compressed. The ground color of *maculicaudus* is in life a bright orange yellow, approaching in some specimens a vermilion. The black spots on the back and sides are very numerous and vary much in size and shape, but never coalesce to form *vertical* bars on the sides of body and tail, though in a specimen from Donnehue's Cave they unite on the sides of body to form horizontal bars, equal in length to the width of the intercostal spaces.

The largest specimens taken were from Donnelson's Cave, Lawrence County, and gave the following measurements: Total length, 156 mm.; snout to cloaca, 61 mm.; snout to gular fold, 15 mm.; width of head, 10 mm.; length of fore limb, 16 mm.; of hind limb, 17 mm.; of tail, 80 mm.; distance from axil to groin, 35 mm.

Several immature specimens, probably of this species, were taken from shallow pools in Mayfield's Cave, and in Wyandotte near the "Throne." They were olive gray in color, mottled with irregular rows of small rounded yellow spots on the back and sides. The adults must, at the spawning season, find their way back as far as these pools or enter the cave through some near-by crevice.

Contrary to Cope and Hay, I do not regard the adults of *S. maculicaudus* as aquatic. While all the specimens noted in the caves were in damp rooms and usually within a few feet of water, none were in the water. In Monroe County, in 1886, I took two specimens from beneath logs a mile or more from any known cave, and half that distance from streams or springs. They were wrongly referred to *S. longicaudus* (Green), a species that I have since found in numbers in pools, beneath flat rocks in the bed of a stream in Putnam County, and also in Vigo County.

In Jordan's Manual of Vertebrates, *S. longicaudus* is given the common name of "Cave Salamander." I have never seen it in caves, nor do I believe that it frequents them, there being no record to that effect. *S. maculicaudus* probably occurs throughout the limestone regions of southern Indiana and Kentucky; but as yet no specimens have been recorded, except from this State.

Family RANIDÆ.

RANA CLAMATA Daudin, Green Frog. A specimen of this common terrestrial frog was taken in a cave near Mitchell, Lawrence County, 450 feet from the entrance. It was evidently following up the stream found in the cave, and was without doubt an accidental visitor.

PISCES. (The Fishes.)

Family AMBLYOPSIDÆ. (The Blind Fishes.)

AMBLYOPSIS SPELÆUS, DeKay. Blind Fish.

DeKay, Zoöl. New York, IV, 1842, 187.
Putnam, Am. Nat. VI, 1872, 10, Pls. I and II.
Jordan and Gilbert, Syn. N. A. Fishes, 1883, 324.
Hay, Indiana Geol. and Nat. Hist., XIX, 1894, 234.
Jordan and Evermann, Fishes of N. Am., 1896, 706.

Of the five species of cave fishes recognized as belonging to the fauna of the eastern United States, this is the largest, yet specimens of it are seldom, if ever, more than five inches in length.

It was found in but three of the caves visited; namely, Sibert's Well Cave, where a single specimen was secured, and in two small caves three miles east of Mitchell, Lawrence County, where 24 specimens were taken. It has been recorded from Sibert's cave by Collett and Cope; from Clifty caves and a cave four miles west of Orleans, Orange County, by Dr. John Sloan; and from Donnelson's and Hamer's caves, Lawrence County, by Collett.

In that portion of Sibert's Cave large enough for exploration, there is but one pool which the fish inhabits, and usually but one or two are found therein. Whether the species breeds in this pool, or in some distant portion of the cave is as yet unknown.

In the Lawrence County caves the species seems to be common, though never more than two and seldom but one were seen at a time. They move very slowly through the water, usually near the surface and close to the edges of the deeper pools which they inhabit. They are wholly non-sensitive to light, but extremely sensitive to touch or any jar or motion of the water. They were readily caught by putting a dip-net very gently into the water a foot or two from them and then making a quick forward and upward scoop. If in still, deep water, they seem to glide, or rather float, on and on, propelled by a scarcely perceptible motion of the caudal fin. One must think of them as ever surrounded by an intense darkness, the prey of every fish-loving animal, as mink or coon, that can swim and see in the darkness, the white skin of the fish readily revealing its presence if the least gleam of light reflects from its sides. No external trace of eyes are to be found in adult specimens, but the loss of sight is in part compensated by numerous tactile papillæ, arranged in ridges on the sides and front of the head.

Of these fishes Cope has written as follows: *

"If these Amblyopses be not alarmed they come to the surface to feed and swim in full sight, like white, aquatic ghosts. They are then easily taken by the hand or net, *if perfect silence is preserved*, for they are unconscious of the presence of an enemy except through the medium of hearing. This sense is, however, evidently very acute, for at any noise they turn suddenly downward and hide beneath stones, etc., on the bottom."

My observations of the specimens taken do not bear out the above statement. We talked and even hallooed close to the fish without causing them to take alarm, but the least movement of the water frightened them, and they darted rapidly away, usually at right angles to the course they were pursuing. The sense of touch, rather than that of hearing, is, in my opinion, the one which has been intensified by long residence in the dark and silent recesses of the caves.

In several instances, as the dip net was raised quickly upward, the fish would leap several inches above the surface of the water in a vain endeavor to escape. In one place in Lawrence County a stream flows out of a cave and through a deep ravine for about 200 yards, and then enters another cave. In both caves the blind fish were captured within 100 feet of the openings, and there is little doubt but that they make their way through the open stream from one cave to the other. The caves and subterranean streams of southern Indiana doubtless form a more or less complete system of subterranean drainage, and through this the blind fish finds its way wherever the water is deep enough to allow it passage.

In captivity this fish eats very little. Dr. Sloan, of New Albany, has kept specimens in an aquarium for 20 months, and says: "They have taken no food, except what has grown up in the water and on the sand in their tank."† "Some of them would strike eagerly at any small body thrown in the water near them, rarely missed it, and in a very short time ejected it from their mouths with considerable force. I often tried to feed them with bits of meat and fresh worms, but they retained nothing.

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*Geol. Surv., Ind., 1872, 162; 1878, 491.

†Packard, Cave Fauna of N. Am., 1889, 24.

On one occasion I missed a small one and found his tail projecting from the mouth of a larger one; I captured and released him.*

In nature they doubtless feed upon one another and upon the blind crayfish and smaller crustaceans which inhabit with them the streams of caves. A number of those captured were "nosing," as they slowly swam, the rocks along the sides of the pools, and it is possible that they gather some organic matter from the slime on these rocks.

The measurements of the largest specimen taken were as follows: Length, four and a half inches; head, three in length; depth, four and a half in length. The color is white, the scales are very small, and the young are born alive.

A second species of blind fish, *Typhlichthys subterraneus* Girard, is said to occur in some of the wells and subterranean streams of southern Indiana, but as yet no definite localities have been recorded.

INVERTEBRATA.

INSECTA.

Representatives of Diptera, Lepidoptera, Coleoptera, Hemiptera, Orthoptera, Thysanura, Myriapoda and Arachnida were secured in the caves visited. The members of each order were sent to different specialists, as follows: The Diptera to J. M. Aldrich, Moscow, Idaho; the single Lepidopteron to Miss Mary E. Murtfeldt, Kirkwood, Mo.; the Coleoptera to H. F. Wickham, Iowa City, Ia.; the Hemiptera to E. P. Van Duzee, Buffalo, N. Y.; the Myriapoda to O. F. Cook, Washington, D. C.; and the Arachnida to Nathan Banks, Sea Cliff, N. Y.

Messrs. Aldrich, Wickham and Banks (in part), and Miss Murtfeldt have prepared papers, which are presented herewith, with supplemental notes added by myself, on habits, etc. Messrs. Van Duzee, Cook and Banks identified the species sent, and the papers as presented were prepared by me. To all the parties mentioned I am under especial obligations for the work done on the specimens submitted.

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*Packard, *loc. cit.*, 127.

ON A COLLECTION OF DIPTERA FROM INDIANA CAVES.

BY J. M. ALDRICH.

This collection embraces 12 species, of which five are herein described as new, one constituting a new genus. Two species are only generically determined. The family Mycetophilidæ is represented by five species, Helomyzidæ by four, and Psychodidæ, Borboridæ and Phoridæ by one each. The Helomyzidæ furnish by far the greater number of individuals. It does not appear that any of these species are wholly confined to a cave life. They show no marked peculiarities of structure and are probably found in shady places generally. None of those previously described, except *Blepharoptera defessa*, have been heretofore known to inhabit caves.

1. MACROCERA HIRSUTA Loew.

Loew, Centuries IX, 5.

One specimen, Truett's Cave, July 9. Slightly larger than Loew's type, thoracic dorsum and pleuræ more infuscated; halteres brownish at tip. Described from the District of Columbia. I have no knowledge of any captures of the species since that time till now.

The specimen noted was taken on the wing in the main room of the cave, 800 feet from the entrance.—W. S. B.

2. SCIARA SPP.

Two species, both small. Of the first, which is dark with a shining black thoracic dorsum, there are seven specimens, six from near the mouth of Salt Petre Cave, the other from Wyandotte Cave. November 5, 1896. Of the second, which is lighter with yellowish brown thorax, one specimen is from Donnehue's Cave, July 14; another, Wyandotte Cave, near Augur Hole.

The specimens of *Sciara* were in all instances taken in small crannies in damp portions of the cave. The "Augur Hole" of Wyandotte is about three-fourths of a mile from the entrance. Species of the genus are quite common in Mammoth Cave, Kentucky, and the young, according to Osten Sacken, live on decaying vegetable matter, fungi, etc.—W. S. B.

3. MYCETOPHILA UMBRATICUS n. sp.

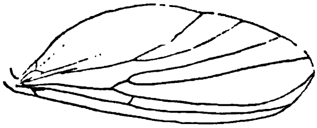
Female. Front dark brown; palpi and three basil joints of antennae yellow. Thorax clay yellow, somewhat pruinose with white, the dorsum somewhat infuscated and provided with numerous stout black hairs along the sides; scutellum and metanotum also brownish, the former with two distinct hairs. Abdomen brown, compressed, the distal part of each segment with a lighter ring, which is broader underneath. Legs pale yellow with a distinct fuscous tinge. Coxæ paler, the front ones with only a few fine hairs at tip; tibiæ wholly without spines except at tip, still on the posterior ones a few scarcely perceptible setulæ. Tarsi elongated, uniformly infuscated, slightly darker than the tibiæ; in the front leg the entire tarsus is about *four times* the length of the tibia, in the middle leg two and a half, and in the hind leg one and a half times. The tibial spurs on the front leg are a fifth the length of the metatarsus; on the other legs a third.

Wings without maculæ, tinged with yellow along the costa and to a less degree—all over the apical half. Venation as figured.

Length, 5.2 mm.; of wing, 4.5 mm.

One female, Shiloh Cave, July 15.

The specimen was taken from beneath a rock about 500 feet from the entrance. A member of the genus has been recorded by Osten Sacken from Bradford Cave, 16 miles from New Albany, Ind. The larvæ live in fungi.—W. S. B.



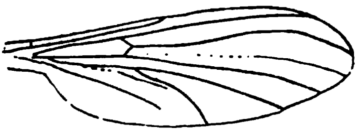
Wing of *Mycetophila umbraticus* n. sp.

ODONTOPODA, new genus.

(ὀδούς tooth; πούς foot.)

(Mycetophilidæ near Glaphyroptera.)

Ocelli three, all large, nearly in a straight line; antennæ 16-jointed, the two basal joints distinct, the others cylindrical, the third longest; palpi four-jointed, first short, second a little longer, third longer than the two preceding, fourth a trifle shorter; coxæ elongated; abdomen (male) long, slender, clavate, composed of seven distinct segments besides the hypopygium. Wings, fourth longitudinal arising near the base; third vein not branched; costal vein not extending beyond tip of third longitudinal; fifth vein forked; auxiliary vein ending in the costa almost half way to the apex; small crossvein nearly equal in length with the first segment of the third vein; fourth vein with a very thin anterior branch arising at the origin of the crossvein, or seemingly from the crossvein itself.



Wing of *Odontopoda sayi* n. sp.

4. ODONTOPODA SAYI, n. sp.

Male. Front black, antennæ brown, except the first three joints, which are yellow; mouth parts yellow; thorax and coxæ yellow, rather pale; the dorsum, however, more acorn-colored without distinct lines. Abdomen brown, the bases of the segments and a larger part underneath of a lighter color; seventh segment distinct, nearly as long as the sixth, hypopygium as long as the seventh, first segment over half as long as the second. Femora and tibiæ yellow, with a brownish tinge; front tarsi black (the others wanting, but doubtless black). Wings of a clear yellow tinge, lighter posteriorly; third vein with a rather strong curvature.

Length, 6 mm.; of wing, 4.7 mm.

One male, Marengo Cave.

The single specimen was on the side of a damp rock, 400 feet from the entrance.—W. S. B.

5. PSYCHODA MINUTA Banks.

Banks, Canad. Ent., XXVI, 331.

One specimen, Salt Peter Cave, Crawford County.

6. ULOMORPHA PILOSELLA Osten Sacken.

Osten Sacken, Proc. Acad. Nat. Sci. Philadelphia, 1859, 342
Osten Sacken, Monograph N. A. Dipt., IV, 233.

One specimen, Porter Cave.

7. BLEPHAROPTERA DEFESSA Osten Sacken.

Osten Sacken, Bulletin U. S. Geol. and Geog. Survey, Vol. III. No. 1, p. 168, note.

One female, Wyandotte Cave.

By the kindness of Professor Packard, I was enabled to see the description of this species. The following sentence is at the end of the description: "*Blepharopteræ* are often found in caves, where they are said to breed in the excrement of bats." The description occurs as a footnote to an article by Professor Packard on "A New Cave Fauna in Utah," but the specimens described were from Hundred Dome Cave, near Glasgow, Kentucky, and were also reported from Wyandotte Cave, among others.

This is the *Anthomyia* of Cope's "Fauna of Wyandotte Cave." Ind. Geol. Surv., 1872, 160. For description and figure see also, Packard's "Cave Fauna of North America," 1889, 80.—W. S. B.

8. BLEPHAROPTERA PUBESCENS Loew.

Loew, Centuries II, 82.

Seven specimens, both sexes: Shiloh Cave, July 15 (1); Salt Peter Cave (2), Coon's Cave (2), Porter Cave (1), Wyandotte Cave (1).

The species was described from Massachusetts.

9. BLEPHAROPTERA LATENS n. sp.

Brownish-black, head, knees, venter and tip of abdomen reddish; two vibrissæ each side.

Head dark red, rather variable in color, vertical triangle black, second fronto-orbital bristle a trifle smaller than the preceding; antennæ dark red, third joint more or less infuscated; face and mouth parts dark red; two large vibrissæ on each side, one a little longer than the other, a narrow strip only is bare below the eye, the remainder of the cheek with rather coarse black pubescence; occiput black above. Thorax black, the roots of wings, halteres and pleural sutures red or yellowish-red; scutellum and mesopleuræ bare, hypopleuræ with a group of four ascending bristles near the upper edge, otherwise bare on the sides except for a little very small scattering black pubescence; underneath, between the fore and middle coxæ, are very numerous bristles. Abdomen black, its tip, the venter, and usually the posterior margin of each segment red. Coxæ and femora black, hairy, the latter stout; trochanters and knees red; tibiæ usually with a considerable red or reddish yellow, especially near the middle; tarsi almost uniformly brown. No special long bristles on the legs. Wings without spots, slightly yellow, the costal bristles small.

Length, 5 to 5 5 mm.; of wing, 4 5 to 5 mm.

Nine specimens, both sexes: Donnehue's Cave, July 14 (3); Shiloh Cave, July 15 (1); Porter Cave, (2); Mayfield's Cave, July 9 (3). Two of the specimens have numerous mites attached to the body.

10. Blepharoptera specus n. sp.

Cinereous, largely yellow, scutellum pubescent.

Head yellowish, vertical triangle and upper part of occiput black, second fronto-orbital bristle smaller than first. Antennæ far apart, yellow, third joint somewhat darker, one vibrissa, the small hairs behind it confined to a narrow strip close to the oral cavity. Dorsum of thorax brown, about the edges more yellow; humeri, the posterior part and the scutellum usually entirely yellow, scutellum with distinct black pubescence besides the usual bristles. Pleuræ yellow with a darker color on the meso and hypopleuræ, the former part bare, the latter with one ascending bristle above and almost imperceptible sparse black pubescence, underneath a few bristles; tegulæ and halteres yellow. Abdomen on the basal half quite blackish, overlaid with cinereous dust, toward the tip yellow; male hypopygium large. Legs principally yellow, but varying in different individuals. In both sexes a row of six or eight bristles in front near the tip of the middle femur; in male a similarly placed row, but higher up, on the hind femur, numbering four or five. Wings slightly yellow, the costal bristles large.

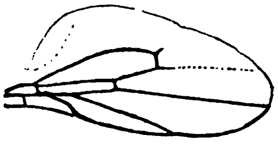
Length, 3.5 to 5 mm.; of wing, the same.

Eighteen specimens, both sexes: Eller's Cave (3); Porter Cave (11); Mayfield's Cave, July 9 (2); Donnehue's Cave, July 14 (1); Wyandotte Cave (1).

The species of Blepharopteræ were the largest and most common Diptera noted in the caves. They were found in the damper portions of nearly every cave visited, on the walls and roof. They were never noted on the wing, except when disturbed, when they would fly but a short distance before alighting. The large species were about as long as, but more slender than, the common house fly. The larvæ, according to Osten Sacken, live in fungi and the excrement of bats. —W. S. B.

11. LIMOSINA TENEBRARUM n. sp.

General color throughout, dark brown, sub-shining. Front, face, edge of clypeus and proboscis the same, the last at the tip yellowish; third joint of antenna rounded, arista slender, microscopically pubescent. Dorsum of thorax with moderate bristles; scutellum concolorous, with four bristles; pleuræ with a little yellow along the sutures; halteres yellow. Legs of simple structure; the tibiæ a trifle lighter than the femora, their tips and the tarsi yellow; hind metatarsus but little thickened, two-thirds of the length of the following joint. Wings as figured. The last section of the third vein perfectly straight, the fourth beyond the posterior crossvein becoming extremely thin, yet traceable to the margin; second and third sections of costal vein subequal. The wings are moderately tinged with brown.



Wing of *Limosina tenebrarum* n. sp.

Length 2 to 2.1 mm.; of wing, 1 to 1.3 mm.

Ten specimens, both sexes; Truett's Cave, July 9 (2); Donnehue's Cave, July 14 (2); Clifty Cave (1); Marengo Cave (1); Wyandotte Cave (3); same, near Augur Hole (1); same, November 6, 1896 (1).

The venation will readily distinguish the species.

The specimens from Donnehue's and Clifty caves were taken from piles of half dry excrement of the raccoon. Those from Wyandotte from beneath stones in the vicinity of remains of dead bats near the "Scuttle." The insects leap a few inches, rather than fly, when disturbed.—W. S. B.

12. PHORA NIGRICEPS Loew.

Loew, Centuries, VI, 99.

Nine specimens, Wyandotte Cave, near Augur Hole.

Taken from the mouldy remains of bread, chickens, etc., near the "Augur Hole," three-fourths of a mile from the mouth, July 27, 1896.—W. S. B.

LEPIDOPTERA.

Family TINEIDÆ.

The discovery of the fact that a small Tineid moth is a common resident in Wyandotte Cave was one of the most interesting results of our study of the cave fauna of Indiana, since no other instance is on record of a member of the order of Lepidoptera being an inhabitant of caves.

Specimens were sent to Miss Mary E. Murtfeldt, of Kirkwood, Mo., who has made a special study of the Tineid group, and she kindly prepared the following paper on the species:

A CAVE-INHABITING MOTH.

BY MARY E. MURTFELDT.

BLABOPHANES FERRUGINELLA Hbn. Specimens of the above named Tineid, with a number of its pupal cases, were recently received for determination from Prof. W. S. Blatchley, State Geologist of Indiana, who gives the following interesting account of its habits: "This insect was found quite abundantly in Wyandotte Cave, 1,000 feet or more from the entrance, in the vicinity of the remains of dead bats and other decaying animal matter, including the dried excrement of cats. Quite a number of the latter inhabit (or frequent?—M. E. M.) the cave and catch the bats as they go in and out of the small openings known as 'Fat Man's Misery' and the 'Augur Hole.' The moths seldom fly, but crawl very rapidly, or leap short distances when disturbed."

In a succeeding letter, Professor Blatchley remarks: "I have Dr. Packard's monograph on 'The Cave Fauna of North America,' but can find no mention of a Tineid or any other moth being found in the caves. Wyandotte Cave has been pretty thoroughly explored before, especially by Professor Cope in 1872, but he also says nothing of moths among its fauna. I have made three visits within the past two years. The first time I took only one moth, but at that time was sight seeing rather than hunting insects. The second and third times I went on more serious business and found the moths plentiful."

* * * * *

Following Professor Blatchley's lead, I also looked through all the literature accessible to me on the subject of cave insects, but without finding any reference to any species of Lepidoptera.

The species received from Professor Blatchley not being represented in my collection, was sent for determination to Dr. C. H. Fernald, of Amherst, Mass., our leading authority on the Micro-lepidoptera, who pronounced it *Blabophanes* (*Tinea*) *ferruginella* Hbn. As Professor Blatchley suggested, it was first described in this country by Dr. Clemens as *Linea croceicapitella.* Clemens' description does not appear to me to apply very closely to the typical form of *B. ferruginella*, and it would seem that it was not at the time recognized as the latter species by Mr. Stainton, then the highest English authority on the *Tineidæ*, but the type in the Philadelphia collection established the identity.

Both Mr. Chambers in his "List of North American *Tineina*," and Professor Riley in the more recent Smith "List of American Lepidoptera," discard the genus *Blabophanes* as not sufficiently distinct from *Tinea*;

but Professor Fernald concurs with contemporary European authors in regarding the scaleless discal spot, in connection with some less conspicuous characters, as of generic value. So far as I have been able to ascertain, no account of the habits or life history of this species has ever been published in this country. It is not included among the species commonly grouped as "clothes moths" by either Drs. Fernald or Riley in their synonymical and popular papers on these species, nor is it mentioned in Mr. Howard's recent bulletin on "Household Pests," and yet it probably occurs where furs and pelts are stored. Indeed, its presence in the depths of the cave can best be accounted for by its accidental introduction on the clothing of guides and visitors.

The species expands from 14 to 18 mm. Length of body, five to seven mm. Head with dense tuft of rust-red hairs. Fore wings oblong, with rounded apex, silky, grey-brown, with slight violet tinge in fresh specimens; a broad ochreous or buff stripe extends along the inner edge, forming a conspicuous dorsal stripe when the wings are closed; discal spot translucent, dingy white. Under wings shining, pale gray-brown. Both wings with long, yellowish gray fringes. Larvæ not observed—probably resembling those of the other case-making species. Pupal cases densely felted, dark gray, subcylindrical, truncate, varying in length from six to eight mm.

Heinemann says that in Europe this species is on the wing during June and July, and again in autumn, indicating two summer broods. It would be interesting to ascertain how far its habit in this respect has been, or would be modified by the unvarying temperature and food conditions of cave existence.

The occurrence of this moth in Wyandotte Cave can not date back many years, for it surely would not have escaped the notice of Drs. Packard and Cope, when their researches were made.

As yet, the species shows no organic or colorational departure from the open air type, but it is not unreasonable to suppose that in years to come there may be perceptible modification in these respects, as has been observed in other cave inhabiting forms.

On the occasion of my first visit to Wyandotte, May, 1895, but few of the moths were noted, and but one was captured. In July, 1896, they were frequent, and in November, 1896, quite common, especially about the "Scuttle," and as far back as "Monument Mountain."

The pupal cases were found attached to small projections of the wall, close to the floor, or on the under side of stones which rested loosely on the floor. In all instances they were in close proximity to decaying remains of bats or other refuse.

The introduction of this European moth into a cave like Wyandotte, and its rapid adaptation to the peculiar environment there found, is an excellent proof of the now commonly accepted theory that all cave animals are but the descendants of seeing forms, which, in the past, have thus accidentally found their way into caves.—W. S. B.

COLEOPTERA.

Mr. Wickham's paper, annotated by me is as follows:

ON A COLLECTION OF INDIANA CAVE BEETLES.

BY H. F. WICKHAM.

The species of cave beetles resulting from the recent explorations are few in number, but several are of considerable interest and add a great deal to our knowledge of the local distribution of life in the Indiana caverns. Several are common epigæal forms, no doubt attracted by the opportunity for shelter or washed in by rains, while others are truly cavernicolous, and partake of the peculiarities in color and development of the visual organs so often exhibited by cave insects.

Attention may be called to the discovery of the blind larvæ of *Quedius spelæus* Horn, the adult having been originally described from Wyandotte Cave. Additional material has also been obtained of *Anophthalmus tenuis* Horn, first collected in the same locality as the *Quedius*.

A detailed report on the material is submitted below:

Family CARABIDÆ.

SCARITES SUBTERRANEUS Fabr. Syst. Eleuth. I, 124. Say, Tr. Am. Phil. Soc., II, 17. Ent. Works, Lec. Ed., II, 448. *Substriatus* Hald., Proc. Acad. Nat. Sci. Phila., II, 54.

This common but variable species has been described under about a dozen names by Le Conte, Chaudoir, and Bonelli, in addition to the ones cited above. A specimen of the form, *substriatus* Hald., was taken by Mr. Blatchley in Porter's Cave. Very widely distributed in North America, from Atlantic to Pacific coasts, and south to Lower California. Usually found under boards or stones; often exhumed in digging gardens.

ANOPHTHALMUS TENUIS Horn, Trans. Am. Ent. Soc., 1871, 327; Id., Geol. Surv. Ind., 1872, 177; Packard, Mem. Nat. Acad. Sci., IV, 75.

Numerous specimens were received, representing the following localities: Wyandotte Cave, on top of "Monument Mountain," near "Throne" and near "Crayfish Spring; Sibert's Well Cave, Mayfield's Cave, Truett's Cave and Shiloh Cave. Very little variation is exhibited, though occasionally there is a tendency toward a greater acuteness of the hind angles of the thorax, quite possibly due to irregular shrinkage of the very soft integuments. This is one of the true cave beetles, and is never found elsewhere. *A. eremita* Horn is described from Wyandotte Cave, but no specimens were found among Professor Blatchley's material.

But one specimen was taken in each of the caves except Wyandotte, where it was rather plentiful in the localities above mentioned, about 20 having been taken along the margin of the rivulet flowing from "Crayfish Spring." It was found only in remote parts of the caves in which it occurred, and was always crawling rapidly over mud, sand, or rocks in damp localities. It is a small, light-brown species, with no vestige of eyes, and appeared wholly unaffected by the light of a candle when the latter was held within a few inches of it.

Like other Carabids, these small blind beetles are supposed to be carnivorous. In Wyandotte specimens of mites, spiders, podurids, and harvestmen were taken in the same localities as the beetles, and probably furnish the latter a scanty supply of food. This species was first described from Wyandotte and has since been recorded from Bradford and Donnelson's Caves.—W. S. B.

PTEROSTICHUS SAYI Brulle, Silb. Rev. Entom., III, 277. *Chalcites* Say, Trans. Am. Phil. Soc., II, 56; Ent. Works, Lec. Ed., II, 479. *Micans* Chaud. Bull. Mosc., IV, 767.

Common above ground over most of the United States east of the Rocky Mountains. Taken in Eller's Cave by Mr. Blatchley.

PLATYNUS CINCTICOLLIS Say, Trans., Am. Phil., Soc., N. S., II, 52; Ent. Works, Lec. Ed., II, 476; Le Conte, Proc. Acad. Nat. Sci. Phila., 1854, 43; Bull. Bklyn. Ent. Soc., II, 46 and 55.

Porter Cave, five specimens not different from above-ground examples in my collection. Inhabits Canada and the northeastern United States, extending south through the Middle States. Not a true cave beetle.

The specimens were taken from beneath stones by the side of the cave stream about 250 feet back from the mouth.—W. S. B.

HARPALUS PENNSYLVANICUS De Geer, Mem. Hist. Ins., IV, 108. Olivier, Entomologie, III, 72. Say, Trans. Am. Phil. Soc., II, 28; Ent. Works, Ed. Lec., II, 456.

Clifty Cave, one specimen from the side of a stream 1,700 feet from the mouth, probably of accidental occurrence. Very abundant above ground throughout southern Canada and the greater part of the United States.

STENOLOPHUS OCHROPEZUS Say, Trans. Am. Phil. Soc., II, 54; Ent. Works, Lec. Ed., II, 478. Dejean, Species General, IV, 411. Le Conte, Proc. Acad. Nat. Sci. Phila., 1868, 377.

Porter Cave, one specimen of the ordinary form. This is another beetle of extremely wide distribution, and there is little doubt of its occurrence in the cave being merely fortuitous.

BRADYCELLUS RUPESTRIS Say, Trans. Am. Phil. Soc., II, 91; Ent. Works, Ed. Lec., II, 505. Le Conte, Proc. Acad. Nat. Sci., Phil., 1868, 381.

Porter Cave, one specimen. Very widely distributed and common over a large part of North America.

Family HYDROPHILIDÆ.

PHILHYDRUS sp. indet.

Porter Cave, one immature specimen in otherwise bad condition; taken from beneath a stone in margin of stream 300 feet from mouth.

Family SILPHIDÆ.

A specimen seeming to belong here is among the material from Coon's Cave. It is in too poor condition to render proper study possible. The best course, in the absence of other material, seems to indicate its preservation until more specimens are secured.

It was taken from beneath a stone 400 feet from the entrance.—W. S. B.

Family STAPHYLINIDÆ.

RHEOCHARA LUCIFUGA Casey, Ann. N. Y. Acad. Sci., VII, 1893, 288. *Calodera cavicola* Garman, Psyche, VII, 1894, 81.

Both the above descriptions were based on specimens taken from small caves near Lexington, Ky. The specimens taken by Mr. Blatchley were identified by Capt. Thos. Casey.

Two specimens were secured in Truetts's Cave, Monroe County, about 700 feet from the entrance. They were found beneath some moldy chicken bones left by preceding visitors. Casey, *loc. cit.*, says: "This interesting species is said to inhabit caves, but, as the eyes are well developed, it probably only seeks their seclusion and darkness during the day." Garman, *loc. cit.*, says of it and another species: "Both have pretty well developed eyes, and may, therefore, live at times in ordinary situations, but they are perfectly at home in the deepest parts of caves, and are at times very abundant there. In all my collecting in ordinary situations I have not seen either species out of doors, and am disposed to consider them true cave dwellers."

Mr. Garman is doubtless right, for no beetle is going to crawl into the deepest recesses of caves each day and emerge again at night. So far the species has only been found in caves, and, like *Quedius spelæus* Horn, has probably inhabited them too short a time to entirely lose the eyes.—W. S. B.

QUEDIUS FULGIDUS Fabr., Mantissa Insectorum, I, 220. = *iracundus* Say, Trans. Am. Phil. Soc., IV, 449; Ent. Works, Ed. Lec. II, 564. Horn, Trans. Am. Ent. Soc., VII, 158. Hamilton, Trans. Am. Ent. Soc., XXI, 366.

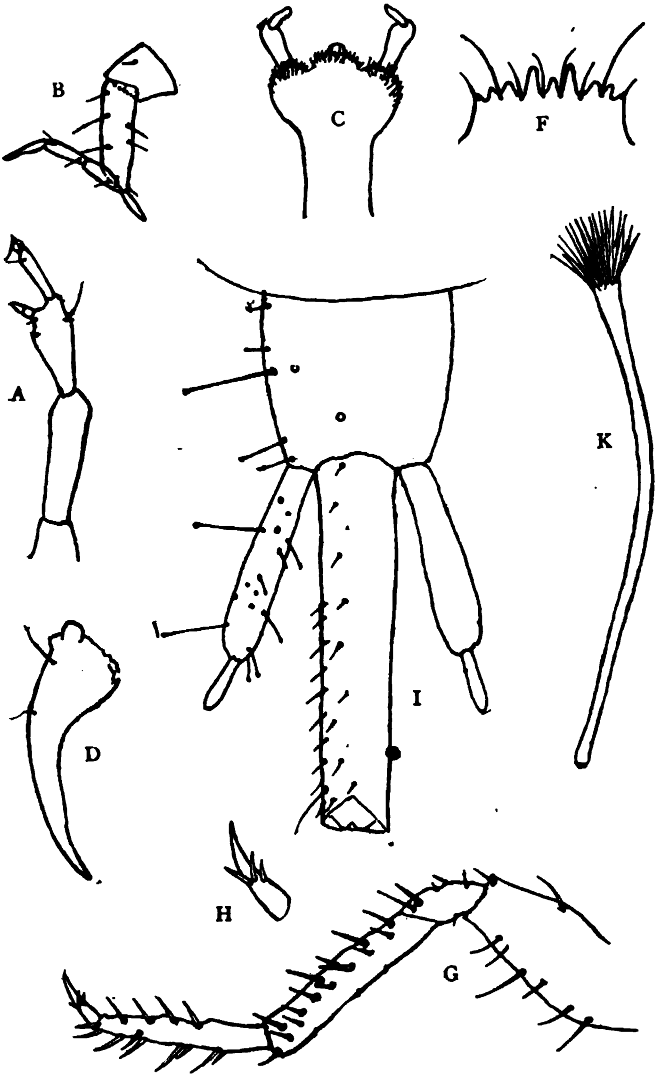
Donnehue's and Marengo Caves. These are true *fulgidus*, with reddish elytra, the head, thorax and abdomen black. Widely distributed (above ground), being found, according to Dr. Hamilton's recent Catalogue, over all of North America, as well as in the other continents, except South America. Recorded from Weyer's and Dixon's Caves in Virginia and Kentucky by Dr. Packard.

Taken from piles of the excrement of raccoons (?) in Donnehue's Cave, and from beneath half decayed boards in Marengo; in both instances in total darkness, 300 or more feet from the entrance.—W. S. B.

QUEDIUS SPELÆUS Horn, Trans. Am. Ent. Soc., 1871, 332; Id., *l. c.* VII, 158; Id., Ind. Geol. Surv., 1872, 179.

Several specimens, Wyandotte Cave, near "Fat Man's Misery;" Mayfield's, Clifty, Donnehue's, Truett's and Coon's Caves. In some of the specimens the elytra and tip of the abdomen tend to become bluish. Varies in size from 6.25 to 12 mm.; Dr. Horn's specimens were 14 to 15 mm. long. A single specimen is known from Colorado.

A number of larvæ are among Professor Blatchley's collections from Donnehue's Cave, Clifty Cave (July 17), and Eller's Cave (450 feet). As no description has hitherto been printed, the following is appended: Larva of ordinary staphylinidous form, very elongate, subcylindrical, slightly tapering. Color, in alcohol, nearly white, occasionally yellowish; the head, thoracic scutes, legs and terminal appendages testaceous or castaneous. Length of largest specimen, 15 mm. Head as long or a trifle longer than the prothorax, sides parallel to near the hind angles, which are rounded; base truncate. Mandibles slender, curved regularly on the outer side, irregularly on the inner, not toothed. The maxillæ are composed of a rather heavy basal joint, followed by a second articulation of about twice the length, which bears a rather slender appendix at its inner distal end; exterior to this appendix is borne the remainder of the maxilla, composed of three joints of very nearly equal length, no one of which is quite half as long as the second. Bristles are few, and as nearly as can be made out are located as follows: One near the base of the first joint, three on the inner and three on the outer edge of the second joint, one near the base of the third; the fourth joint bears one near the base and one near the tip. The fifth joint is not armed and is rapidly narrowed near the middle, continuing slender to tip. Labium very small, free portion elongate, nearly parallel-sided to near the tip, becoming rapidly broader and tri-lobed at apex, which is finely and densely bristled. Palpi borne on the outer lobes, two jointed, basal joint much the larger. The middle lobe bears a small blunt process articulated to its center. Above the mouth, the margin of the head (clypeus?) is armed with nine teeth, of which one on each side of the middle tooth is larger and longer than the remainder. The outer three teeth on each side are the shortest.



QUEDIUS SPELÆUS. (Larva.)

There are eight long bristles near the edge of this organ, of which the one next the outer is much longer than the rest. Antennæ with short basal joint, second much longer, third shorter than the second, gibbous beyond the middle, the gibbosity with an external and an internal long bristle. On the inner edge of this gibbosity, near the tip of the joint, arises also a very small two-jointed appendix, near the base of which is a small bristle. The fourth joint proper is shorter than the third, slender, tipped with three minute bristles and with a larger one inside, near the tip. Eyes wanting. Prothorax at base about as wide as the head, sides arcuately narrowing to apex; pronotal scute margined all around, meso and metathorax slightly broader, but much shorter, the dorsal scutes margined. Legs moderate in length, the coxæ rather elongate and with about six spines on their outer face, two or three on the inner. Trochanter and femur spinose, the latter joint about as long as the coxa. Tibia shorter, very spiny, not broader at tip; claw single, slender, slightly curved, tri-spinose before the middle. Abdomen with the first four segments shorter than the remainder, the first narrower than the three following. The fifth, sixth, seventh and eighth are about equal in length among themselves, but gradually narrower. Ninth much more slender, bearing at apex the anal proleg, which is parallel-sided, finely spinose, less so near the base. The anal appendages are two in number, two-jointed, the second joint small and short. They arise one on either side of the proleg, and are armed with a number of curious brush-tipped spines, of which two on the outer edge are longer than the others. These brush tipped spines are also to be found on the sides of the ninth segment.

The accompanying plate will illustrate the points of structure brought out above. The antenna is represented at a; b represents a maxilla; c, the labium; d, the mandible; f, the front margin of the head; g, a leg; h, claw of same; i, the ninth abdominal segment with its appendages, and k, a brush-tipped spine.

Both the mature insects and the larvæ of *Quedius spelæus* were in all instances taken in decaying organic matter, or beneath stones in the vicinity thereof. Most of the larvæ were in piles of the excrement of raccoons. Although Cope and Packard both refer to this as a "twilight species," all specimens taken by me were in total darkness, those in Wyandotte Cave being 1,000 feet from the mouth.—W. S. B.

CRYPTOBIUM BICOLOR Grav., Coleoptera Microptera, 179. Say, Trans. Am. Phil. Soc., IV, 454; Ent. Works, Ed. Lec., II, 570. Horn, Trans. Am. Ent. Soc,, XII, 92.

One specimen, Porter's Cave; undoubtedly accidental in occurrence, as it is like above ground specimens.

HEMIPTERA.

Family CORISIDÆ.

CORISA sp.?

No members of the order Hemiptera have as yet been recorded as inhabiting caves. In dredging the stream flowing through Shiloh Cave, Lawrence County, two specimens of aquatic bugs belonging to the genus Corisa were taken about 300 feet from the entrance, and in the same pool as the blind crayfish, *Cambarus pellucidus* (Tellkamp).

The bugs were sent to Mr. E. P. Van Duzee, who wrote me concerning them as follows: "Your species belong to the group represented by *C. erichsonii*, *limitata* and *stigmatica*, but it differs a little from each and may be distinct from any. It seems to be nearest *erichsonii* Fieb, though I would dislike to label it as such without a pretty emphatic question mark."

The compound eyes of the insect appear well developed, and it may be only an accidental visitor in the cave.

ORTHOPTERA.

Family LOCUSTIDÆ.

CEUTHOPHILUS STYGIUS (Scudd).

Raphidophora stygius Scudd., Proc. Bost. Soc. Nat. Hist. VIII, 1861, 9.
Pack., Amer. Nat., V., 1871, 745.
Ceuthophilus stygius Scudd. Bost. Jour. Nat. Hist., VII, 1862, 438.
Pack. Guide Stud. Ins. 1869, 565.
Riley Stand. Nat. Hist., II, 1884, 184.
Packard, Mem. Nat. Acad. Sci., IV, 1888, 70, 83.
Brunner, Monog. Stenop., 1888, 309.
Blatch., Proc. Ind. Acad. Sci., 1892, 148.
Scudd., Proc. Amer. Acad. Sci., XXX, 1894, 33.
Ceuthophilus sloanii Pack., Ann. Peab. Acad. Sci., V, 1873, 93.
Id., Mem. Nat. Acad. Sci., IV, 1888, 71, 83.

This "cave cricket" occurs abundantly in crevices in the walls and roof near the mouths of Wyandotte, Little Wyandotte, Sibert's Well Cave and Salt Petre Cave, Crawford County, and a few immature specimens, pronounced by Mr. S. H. Scudder to be the same species, were taken in Porter's, Truett's and Strong's Caves, 80 miles farther north. In the Crawford County caves no specimens were found farther back than 250 feet from the mouth; in the other caves they were found back beyond the reach of any rays of light.

The adults of this species seem to be more or less gregarious. In one instance, in Sibert's Well Cave, more than 20 were found in a small cranny in the wall. They were grouped in a circle, in a space about six inches square, with their antennæ pointing toward the center of the circle, and appeared to be holding a conference or cricket convention.

In regard to the life history of this insect, but little is known. I found a number of specimens of the half-grown young in Sibert's Cave in May, 1895. The adults were common in July, 1896; and in November, the young about one-third the size of mature specimens were frequent in Salt Petre Cave, but could not be found elsewhere.

The species may be represented in winter by the young as well as by eggs, as is the case among some other members of the genus.*

According to Mr. Rothrock, *stygius* is sometimes found as far back in Wyandotte Cave as the top of "Monument Mountain." I searched for it there on the three dates above mentioned and could find no specimens.

In Salt Petre Cave, where in July they were very plentiful, all were found within 100 feet of the entrance. They were never seen on the floor, unless they leaped there when disturbed, but were found resting on the sides of small projections and in small cavities of the walls or roof, with their antennæ spread out before them. If a lighted candle were held close to them they paid no attention to it, but were very sensitive to its heat and to touch. When disturbed they leap with agility, sometimes to a distance of six feet, but with a little care can usually be readily picked up with the fingers before they become frightened.

This is the largest of the seven species of Stone or Camel crickets belonging to the genus Ceuthophilus which are known to occur in Indiana.

A number of the larger specimens taken in Salt Petre and Sibert's caves measured as follows:

	Males.	*Females.*
Length of body	30.0 mm.	26.0 mm.
Length of pronotum	7.5 mm.	6.5 mm.
Length of front femora	15.0 mm.	12.5 mm.
Length of hind femora	26.0 mm.	24.0 mm.
Length of hind tibia	27.5 mm.	25.0 mm.
Length of antennæ	103.0 mm.	96.0 mm.
Length of ovipositor		16.0 mm.

But little variation was noted in the color of mature specimens, though they varied much in size.

The immature ones from caves in Monroe and Owen Counties were darker than typical *stygius*, and were found on the floor of the caves—in one or two instances beneath loose rocks. From their habits, I am somewhat inclined to doubt their being *stygius*, since it is difficult to always name correctly an immature specimen. The *C. sloanii* of Packard, from Bradford and Little Wyandotte Caves, has been pronounced by Scudder, who has recently monographed the genus, to be the young of *stygius*.

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*See Proc. Ind. Acad. Sci., 1892, 141.

THYSANURA.

Family PODURIDÆ.

DEGEERIA CAVERNARUM Packard.

Packard, Memoir Nat. Acad. Sci., IV, 1888, 66, Pl. XVI.

This small Thysanuran was described from specimens taken in Little Wyandotte Cave, and has been recorded also from Bradford Cave, and from several Kentucky caverns. It was found by our party to be the most common form of life in each of the following caves: Mayfield's, Truett's, Eller's, Shiloh, Clifty, Marengo, Little Wyandotte and Wyandotte.

Like most other cave inhabiting insects, it occurs only in comparatively moist places, often swarming by thousands beneath or on the surface of damp rocks, especially where organic matter, such as the remains of lunches, drippings from candles, decaying wood, etc., was scattered.

It has the power of leaping several inches by means of a long, spring-like appendage bent under the hind body, which on being released throws the insect high in the air.

Since the species is so common in Indiana caves, its description, as given by Packard, is copied herewith, as follows:

> "Whitish, with a slight yellowish tint; usually blind; no traces of eyes. Body of the usual form of the genus; antennæ of great length, two-thirds as long as the body, and more than twice as long as the head; basal joint longer than usual; fourth joint very long and slender. Legs: Last joint with fine, slender scales; the claws much as in *D. grisea* Pack., but the spines on the larger claw are less distinct and the tenent hair shorter; the spring long and slender; the second joint serrulate along the under side nearly to the base: third (terminal) joint long and slender, ending in three teeth; the terminal tooth claw-like, as usual. The collophore is large and well developed.
>
> "Length of body, without the spring 3 mm."

This Podurid doubtless forms much of the food of the small spiders, harvestmen and beetles which inhabit the caves.

Two additional members of the order Thysanura, viz.: *Campodea cookei* Pack., and *Machilis sp.*, are recorded by Packard* as occurring in Wyandotte, but no specimens of either were taken by us.

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*Mem. Nat. Acad. Sci., IV, 1888, 15, 67.

MYRIAPODA.

POLYZONIUM ROSALBUM (Cope).

A single specimen from Evaston's Cave, 100 feet from the mouth. Probably an accidental visitor, the species being a rather common aboveground form, living beneath half-buried logs.

SPIROSTREPHON LACTARIUM (Say).

This is a common above-ground species throughout the eastern United States, and, according to Packard, was probably the parent of *Pseudotremia cavernarum* Cope, the common species found in Wyandotte Cave. A single specimen was taken from the roof of Mayfield's Cave, 700 feet from the entrance.

PSEUDOTREMIA CAVERNARUM Cope.

Pseudotremia cavernarum Cope. Jour. Am. Phil. Soc., XI, 1869, 179. Id., Trans., Am. Ent. Soc, III, 1870, 67.
Bollman, Proc. U. S. Nat. Mus., XI, 1888, 405. (Wyandotte, Little Wyandotte, Bradford's and Marengo Caves.)
Packard. Mem. Nat. Acad. Sci., IV, 1888, 61, Pl. VI.
Cook and Collins, Ann. N. Y. Acad. Sci., IX, 1896, 36. (Wyandotte and Marengo Caves.)

Spirostrephon cavernarum Cope. Am. Nat., VI, 1872, 409.
Id., Geol. Surv. Ind., 1872, 161, 167.
Id., Geol. Surv. Ind., 1878, 493, 499.

This species was found to be very common in Marengo, Wyandotte and Little Wyandotte Caves. It frequents damp localities, especially masses of stalagmite over which water is trickling, and is usually crawling very rapidly, for one of its kind. It has not been taken in the State north of Crawford County, and outside of the State only at a few points in Virginia and Tennessee.

The fact that Mammoth Cave and vicinity has a peculiar myriapod, *Scotherpes copei* (Pack.); the northern caves of Indiana, another—*Conotyla bollmani* (McNeill), and the Virginia caves a third, *Zygonopus whitei* Ryder, while in the Wyandotte region we find abundantly the *P. cavernarum* is strong evidence of the origin of each of these species from a different type which inhabited the region in which the corresponding cave form is now found. A closely allied species, *P. carterensis* Packard, has been recorded* from Sibert's Well Cave. It was previously known from Carter Caves, Kentucky. No specimens were secured by us.

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*Bollman, Proc. U. S. Nat. Mus., XI, 1888, 405.

CONOTYLA BOLLMANI (McNeill).

Trichopetalum bollmani McNeill, Proc. U. S. Nat. Mus., X, 1887, 330. (Mayfield's Cave.)

Scotherpes bollmani Bollman, Proc. U. S. Nat. Mus, XI, 1888, 405. (Mayfield's, Neeld's, Truett's and Coons' Caves, Monroe Co.; Phitts' and Donnehue's Caves, Lawrence Co.)

Conotyla bollmani Cook and Collins, Ann. N. Y., Acad. Sci., IX, 1896, 76. (Localities as above.)

This appears to be an abundant myriapod in the caves of Lawrence and Monroe Counties. It was taken by us in all the caves cited above which were visited, and also in Porter's Cave, Owen County, but was not noted in the caves of Crawford County. It was usually found beneath stones in the vicinity of decaying organic matter.

SCYTONOTUS GRANULATUS (Say).

Another epigæal species, a single specimen of which was taken from Little Wyandotte, 200 feet from the entrance. From this cave a few specimens of *Cambala annulata* (Say), another above-ground species, were taken by Packard and recorded in his "Cave Fauna," p. 65.

LITHOBIUS SP. ?

A single specimen from Shiloh Cave, 200 feet back. Of this Mr. Cook wrote: "This may be a true cave species, since the eyes seem not normally pigmented, but this is perhaps due to the contraction of the tissues in alcohol. The anal legs are wanting, so that a satisfactory specific determination can not be made."

ARACHNIDA.

The members of this group were named for me by Mr. Nathan Banks, Sea Cliff, N. Y., who also prepared the descriptions of the two new species which follow:

ARANEIDA (The Spiders).

Family AGALENIDÆ.

TEGENARIA CAVICOLA n. sp.

Length female (immature) 6 mm. Cephalothorax pale, eyes on black spots, more or less connected; a black line from the P. S. E. backward uniting at dorsal groove, a fine line from the P. M. E. forked and one branch joining the line from P. S. E., three dark spots each side, a black seam, and a line each side behind from the dorsal groove; mandibles pale; legs pale, with two dark rings on the femora and tibiæ, incomplete on the former, also blackish at tips; sternum blackish, paler in center; abdomen pale above, with many black marks so thick behind as to leave only a few white chevrons, in front a median spear mark, and spots each side; venter blackish with a white stripe each side. Cephalothorax quite broad, much narrowed in front, P. M. E. about their diameter apart, fully as far from the equal P. S. E.; A. M. E. smaller, less than diameter apart and closer to the larger A. S. E. Mandibles long, vertical; legs long and slender; sternum broad, sides rounded, pointed between hind coxæ; abdomen nearly twice as long as broad, convex above, rather blunt at tip.

Two young females from Salt Petre Cave, Crawford County, Indiana. Quite different from any eastern Tegenaria, more like *T. californica*.

This species was taken about 75 feet back from the entrance of the cave. It spins a handsome web, basket-like in form, attached to the roof. When approached with lighted candle, the spiders came down from a crevice in the roof on the side of the web nearest us. Several were seen but only two taken.—W. S. B.

Family EPEIRIDÆ.

META MENARDI Latr.

This was found to be the most common spider in Indiana caves. It was taken in Mayfield's, Strong's, Donnehue's, Donnelson's, Clifty, Wyandotte and Salt Petre Caves, usually within 250 feet from the mouth. The specimens varied much in age and size. They were usually found hanging from the roof or projection of wall by a single thread, with a loosely constructed web near by. According to Banks, "The Meta is not uncommon in dark and shady places in the eastern States, and probably elsewhere, but much more abundant in small caves. It is an European species."

Family LYCOSIDÆ.

DOLOMEDES URINATOR Hentz.

An above ground form which was taken about 50 feet back from the mouth of Donnelson's Cave.

Family THERIDIDÆ.

THERIDIUM PORTERI n. sp.

Length of female, 3.8 mm., femur I, 3 mm. Cephalothorax pale yellowish, infuscated on the pars cephalica, and a blackish marginal seam. Mandibles yellow-brown; sternum a little darker; legs pale, yellow-brown marks as follows: a stripe in front of femur I, a spot on the middle of femora II and III, a ring at end of all femora, whole of patellæ, and bands before middle and at tip of all tibiæ and metatarsi, very broad on the latter joints. Abdomen light or dark gray, often with two large dark patches above near the base, and a larger, irregular transverse mark behind, besides some scattered dots. Cephalothorax rather short and broad; mandibles normal; sternum nearly triangular, longer than broad; abdomen globose, high and convex. The epigynum shows two small red circles connected behind by an emarginate ridge. Eyes well developed, all about equal in size, P. M. E. about their diameter apart, as far from the P. S. E.; A. M. E. hardly their diameter apart, rather closer to the A. S. E.; S. E. touching. What I take to be the male is about the same size, with reddish, longer legs, and a less globose abdomen, wholly pale gray. The stout, black style is coiled once around the top of the bulb, and its tip rests in a long, stout, black sheath, very prominent. Five females and one male, Porter Cave, Indiana.

A common species in a large room with low ceiling near the source of the cave. They were found suspended by a single thread, with scattered threads of webs near by. Near each specimen was always one, and sometimes two, small cocoons of the usual form for the genus Theridium, and white in color. This species was also noted in the first room of Truett's cave.—W. S. B.

TMETICUS TRIDENTATUS Em.

A single pair were secured from the floor of Porter Cave, Owen County, 250 feet from the mouth.

NESTICUS CARTERI Em. Am. Nat., IX, 1875, 279; Id., Pack., Mem. Nat. Acad. Sci. IV, 1888, 57.

This species was taken in Porter's, Coons' and Marengo Caves. It had been before recorded only from caves in Carter County, Kentucky. It is a small, light yellow species, and was found crawling over the surface of damp rocks, 200 to 500 feet from the entrance.

This and the next species are wandering spiders, and spin no web. They evidently feed upon the Thysanuran, *Degeeria cavernarum* Pack., which was abundant wherever they were found.

PHANETTA SUBTERRANEA (Em).

Linyphia subterranea Em, Am. Nat., IX, 1875, 279.
Id., in Pack., Mem., Nat. Acad. Sci.., IV, 1888, 57.

This small, pale, pinkish-brown species was described from specimens taken in Wyandotte. We found it scarce, but three or four specimens being seen. It has essentially the same habits as *Nesticus carteri* Em.

PHALANGIDA (The Harvestmen).

Family PHALANGODIDÆ.

SCOTOLEMON FLAVESCENS (Cope.)

Erebomaster flavescens Cope., Am. Nat., VI, 1872, 420, figs. 114–115.
Id., Geol. Surv. Ind., 1872, 168, 177.
Id., Geol. Surv. Ind., 1878, 501.

Phalangodes flavescens Pack., Mem. Nat. Acad. Sci., IV, 1888, 49, pls. XII and XV.

This is the most common Arachnid in Wyandotte Cave, its only previously known locality. It is a pale yellow species, with distinct eyes, although it occurs in remote portions of the cave, being most common on the damp stalagmite at the base of the "Pillar of the Constitution" and on top of "Monument Mountain." What they feed upon is as yet unknown, though probably, like the two spiders above mentioned, the Podurans form a portion of their diet. A few specimens were secured in Clifty Cave, Washington County.

PSEUDOSCORPIONIDA (The Chelifers).

Family OBISIDÆ

CHTONIUS PACKARDII Hagen.

Chtonius packardii Hag., Zoöl. Anzeig., II, 1879, 399.
Id., Amer. Entom., III, 1880, 83.
Pack., Mem., Nat. Acad. Sci., IV, 1888, 43.

The type specimens of this small, semi-blind chelifer came from Wyandotte. None were secured on our visit in July, but in November three specimens were obtained from the surface of damp rocks one-half mile or more from the entrance. It moves slowly along with its chelæ held in the air in front, and, being less than one-tenth of an inch in length, is very likely to be overlooked unless especial search is made for it. It has been taken in Mammoth and other Kentucky caves, and varies much in regard to the development of the eyes, some having two eyes, with the cornea as usual; some having no cornea, but retaining the silvery dot indicating the retina, and others being totally blind. *

ACARINA. (The Mites.)

But little has hitherto been published concerning cave mites, and the descriptions of the different species are brief and confusing. Examples of two species were obtained in Wyandotte Cave as follows:

DIPLOTASPIS sp. ?

This was found to be a common parasite on the wings of both living and dead bats. It is a very small, white form, and probably occurs on bats wherever found. It may prove to be the young of the following:

DIPLOTASPIS sp. ?

A single specimen of a larger, dark-colored form was found on a damp rock near the remains of waste food, close to the "Augur Hole."

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* Pack., Mem. Nat. Acad. Sci., 1888, 47.

CRUSTACEA.

On a Collection of Crustaceans from Indiana Caves.

BY W. P. HAY.

Family Gammaridæ.

Genus Crangonyx Bate.

Crangonyx gracilis Smith.

Crangonyx gracilis Smith, Am. Jour. Sci. Ser., 3, II, 1871, 453.
Id., Rep. U. S. F. C., 1872–73, 654.
Forbes, Bull. Ill. St. Lab. Nat. Hist., No. 1, 1876, 6.
Hay, O. P., Am. Nat., XVI, 1882, 241.

A number of specimens representing this species were taken from the following caves: Eller's, Mayfield's and Donnohue's. The animal is not one given to life in such situations, and I am of the opinion they are to be regarded as accidental visitors only, having been washed by heavy rains into the cave streams, from which they have been unable to make their escape.

Packard in Mem. Nat. Acad. Sci., IV, 1888, p. 36, says that *C. gracilis* "occurs as far south as Grand Rapids, Mich., whereas Forbes, *loc. cit.*, had already stated that it was common in southern Illinois. It is much the larger of the three species taken in Indiana caves. It was first known to occur in Mayfield's Cave in 1886, when it was taken by the late C. H. Bollman. From the nature of the stream in this cave I do not think it is possible for it to escape, and the facilities are, therefore, excellent for a future study of the length of time necessary to bring about organic changes due to cave environment.—W. S. B.

Crangonyx vitreus (Cope).

Stygobromus vitreus Cope., Am. Nat. VI, 1872, 422.
Id., Geol. Surv. Ind., 1872, 165, 181; 1878, 408.
Crangonyx vitreus Smith, Rep. U. S. F. C., 1872–73, 656.
Id., Am. Jour. Sei. Ser. 3, IX, 1875, 476–7.
Packard, Mem. Nat. Acad. Sci, IV, 1888, 34.

This species is represented in the collection by nearly a dozen small specimens which were taken from a wooden trough in Salt Petre Cave, Crawford County. The crustaceans originally described by Cope, and later by Smith, were from Mammoth Cave of Kentucky. The present record, therefore, extends their range very materially.

CRANGONYX PACKARDII Smith.

Crangonyx packardii Smith, Am. Jour. Sci. Ser. 3, IX, 1875, 476–7.
Packard Mem. Nat. Acad. Sci. IV, 1888, 35.
Crangonyx vitreus Packard, 5th Rep. Peabody Acad. Sci., 1873, 95.

Seven specimens of this subterranean crustacean were taken at Crawfish Spring in Wyandotte Cave. They differ from *C. vitreus* in having small eyes, and are evidently more closely related to *C. gracilis*, from which both have probably descended.

The type specimens of this species were obtained from wells in Orange County by Dr. M. N. Elrod. Others were afterwards secured from a well in New Albany by Dr. John Sloan. These are its only previous records. It swims very rapidly, jerking itself hither and thither through the water in a zigzag course, and is extremely difficult to capture. In July a number of specimens of this or the preceding species were noted in the "Spring of Deception," near the "Throne," in Wyandotte, but all escaped capture. In November the water in this spring had disappeared, and the bottom was covered with very soft, sticky mud. In this a number of small holes resembling the burrows or pits of angle worms were noted. Each had numerous particles of dry, sand-like grains of mud about the mouth. The pits were probed and cut out with a knife, but no living form could be found. In my opinion they were formed by the small Crangonyx, of which no trace remained.—W. S. B.

Family ASELLIDÆ.

Genus CÆCIDOTÆA Packard.

CÆCIDOTÆA STYGIA Packard.

Cæcidotæa stygia Packard, Am. Nat. V, 1871, 751.
Id., Rept. Peabody Acad. Sci., V, 1873, 95.
Smith, Rep. U. S. F. C., 1872–73, 661.
Hubbard, Am. Etom., N. Ser. I, 1880, 36, 98.
Packard, Mem. Nat. Acad. Sci., IV, 1888, 29.
Cæcidotæa microcephala Cope, Am. Nat. VI, 1872, 411.
Id., 3d and 4th Rep. Geol. Surv. Ind., 1872, 163, 174.
Smith, Am. Nat. VII, 1872, 244.

Asellus stygius Forbes, Bull. Ill. State Lab. Nat. Hist., I, 1876, 11.

Numerous specimens of this crustacean were taken from the following caves: Strong's, Eller's, Mayfield's, Marengo, Wyandotte, Salt Petre and Evaston's.

Although *Cæcidotæa stygia* is apparently strictly subterranean in its habitat, it may occur in many places remote from the cave regions. It has been reported from central Illinois, where it frequents tile drains and wells. I have found it in similar situations in central Indiana and have frequently taken it from wells in the vicinity of Indianapolis.

Described originally from an injured specimen, the affinities of this crustacean were for a long time in dispute, and the literature is, for so small an animal, somewhat voluminous. The first complete description was given by Forbes (see synonymy), who regarded it as being generically identified with the water sow-bugs, which are so common in our ponds and streams. The genus Cæcidotæa is now regarded as valid and definable by other characteristics more important than the lack of organs of vision.

This was the most common crustacean noted in Indiana caves. It was usually found singly, swimming or crawling slowly through the water of small cave streams, and was easily picked up with a pair of forceps. In Marengo Cave, however, it was gregarious, hundreds being found on the under side of some rotten boards floating in a pool, 2,000 feet from the entrance. The specimens taken varied much in size, and those from Marengo were much darker in color than the others.—W. S. B.

Family ONISCIDÆ.

Genus PORCELLIO Latreille.

PORCELLIO (sp. indet.).

A single specimen, which I refer to this genus, was taken near the mouth of Wyandotte Cave. On account of the lack of the necessary literature I am unable to carry the identification further.

Family POTOMOBIIDÆ.

Genus CAMBARUS Erichson.

CAMBARUS PELLUCIDUS (Tellkampf).

Astacus pellucidus Tellkampf, Arch. Anat. Physiol. u. Wissensch. Med., 1844, 383.
Astacus (Cambarus) pellucidus Erichson, Arch. Naturgesch., XII, 1846, 95.
Cambarus pellucidus Hagen, Ill. Cat. Mus. Comp. Zoo., 1870, No. III, 55.
Putnam, Proc. Bost. Soc. Nat. Hist., XVII and XVIII, 1875.
Faxon, Mem. Mus. Comp. Zoo., X, 1885, No. 4, 40.
Packard, Mem. Nat. Acad. Sci., IV, 1888, 38.
Hay, W. P., Proc. U. S. Nat. Mus, XVI, 1893, 283.
Id., 20th. Rept. Geol. Ind., 1895, 482.
Orconectes pellucidus Cope, Amer. Nat., VI, 1872, 410.
Id., 3d and 4th Rept. Geol. Ind., 1872, 173.
Orconectes inermis Cope, Amer. Nat., VI, 1872, 410.
Id., 3d and 4th Rept. Geol. Ind., 1872, 173.

Twelve specimens of this curious and well-known blind crayfish were collected in the following caves: Wyandotte and the Well caves in Crawford County; Shiloh Cave in Lawrence County; cave east of Mitchell, Lawrence County; Clifty Cave, Washington County. The following list of localities, taken from the Twentieth Annual Report of the Indiana State Geologist, will give an idea of the range of this species: Shiloh, Down's, Donnehue's, Connelly's and Donnelson's caves in Lawrence County; cave at Clifty in Washington County; cave near Paoli and in Lost River, Orange County; Wyandotte, Wildcat and Marengo(?) caves in Crawford County.

The species was first described from specimens from Mammoth Cave in Kentucky, and it has since been taken in other cave streams of that State.

In Indiana the blind crayfish probably occurs throughout the whole cave region and is to be looked for in every cave in which there is a running stream. Careful examination of cave bed streams ought, also, to show its occasional occurrence outside of its subterranean homes. During the heavy rainfalls the water rushes with great violence through the caves and doubtless frequently carries the animals out to the rivers. Here its light color, soft shell and defenseless condition would prove such a heavy handicap that in the struggle for existence its life would be of very short duration.

The blind crayfish inhabits shallow pools with muddy bottom rather than rapid flowing water. It moves slowly with its antennæ spread out before it, and gently waving to and fro, feeling, as it were, every inch of its way. It is wholly non-sensitive to light, and seemingly so to sound, but when disturbed by any movement in the water it is extremely active, much more so than ordinary terrestrial forms, leaping upward and backward with quick, powerful downward blows of its abdomen.—W. S. B.

CAMBARUS PELLUCIDUS TESTII Hay.

Cambarus pellucidus testii Hay, W. P., Proc. U. S. Nat. Mus. XVI, 1893, 283.
Id., 20th Ann. Rept. Ind. State Geol., 1895, 484.

One specimen was examined which was taken from Mayfield's Cave in Monroe County.

So far as our present knowledge goes this peculiar sub-species occurs only in the above mentioned cave and a neighboring one—Truett's.

CAMBARUS BARTONII (Fabricius).

(?) *Astacus bartonii* Fabricius, Suppl. Entomolog. Systemat, 1798, 404.
Cambarus bartonii Hagen, Ill. Cat. Mus. Comp. Zoo. No. III, 1870, 75.
Faxon, Mem. Mus. Comp. Zoo. X, No. 4, 1885, 59.
Hay, W. P, 20th Ann. Rep. Ind. State Geol., 1895, 487.

This crayfish, although usually regarded as an inhabitant of surface waters, seems to take very kindly to a subterranean abode when the opportunity is offered. Whether it passes its whole life here or makes visits to the outside is a question, but in several cases I have taken the animal in places from which I can scarcely believe it could have made its escape. In the present collection the specimens came from Strong's Cave in Monroe County; Clifty Cave, Washington County; Donnehue's Cave, Lawrence County, and Spring Cave, Owen County. In the Clifty Cave *C. bartonii* was found within 50 feet of individuals of the eyeless *C. pellucidus*.

BIBLIOGRAPHY OF INDIANA CAVES AND THEIR FAUNA.

BY W. S. BLATCHLEY.

The following is a list of such papers and works as have come to my notice, referring in whole or in part to Indiana caves and their fauna. Brief attention is called to the particular feature of each pertaining to Indiana caves.

BROWN, DR. R. T.—In Trans. Ind. State Agr. Soc., 1853, 309. Describes very briefly Wyandotte; mentions a "lizard about three inches long and without eyes as the only living inhabitant of the cave."

BROWN, DR. R. T.—13th Rep. Ind. Geol. Surv., 1883, 78. Gives a brief description of Porter's Cave.

COLLETT, JOHN.—Rep. Ind. Geol. Surv., 1872, 149. Gives a brief description of Wyandotte and Little Wyandotte caves.

COLLETT, JOHN.—Geol. Surv. Ind., 1873. Describes briefly Shiloh Cave, p. 289; Dry Cave, p. 290; Connelly's Cave, p. 298; Hamer's Cave, p. 303; Donnelson's Cave, p. 304. Gives brief list of animals found in the last three caves mentioned.

COLLETT, JOHN.—Geol. Surv. Ind., 1875, 321. Mentions briefly Miller's (Porter's) Cave, Owen County.

COLLETT, JOHN.—"Wyandotte Cave."—Rept. Ind. Geol. Surv., 1878, 456. Gives a rather full popular description, accompanied by map, of the cave. Treats also Salt Peter Cave and Little Wyandotte on p. 507; King's Cave, Harrison County, on p. 370, and Rhode's Cave, Harrison County, on p. 360.

Cope, E. D.—Ind. Daily Journal, Sept. 5, 1871.

Cope, E. D.—"On the Wyandotte Cave and Its Fauna."—Am. Nat., VI, 1872, 406. Makes brief mention of the more interesting features of the cave and gives an account of its fauna as then known, together with descriptions of a number of forms supposed to be new.

Cope, E. D.—Reprint of the above in Reps. Ind. Geol. Surv., 1872, 157, and 1878, 487.

Emerton, J. H.—"Notes on Spiders from Caves in Kentucky, Virginia and Indiana." Am. Nat. IX., 1875, 278. Describes and figures *Linyphia subterranea*, a spider from Wyandotte.

Flint, E. H.—"History and Geography of the Mississippi Valley," 3d Ed., 1833, 389. Contains a brief description of Wyandotte Cave, under the name of "Epsom Salts Cave."

Hagen, Dr. H.—"The Blind Crayfish"—Am. Nat., VI, 1872, 494. States that Cope's genus, *Orconectes*, proposed for the blind crayfish is not valid, and that the species *O. inermis* from Wyandotte is but a form of *Cambarus pellucidus* (Tellk).

Hay, W. P.—"Observations on the Blind Crayfishes of Indiana, with a description of a New Subspecies."—Proc. U. S. Nat. Mus., XVI, 1893, 283. Plates.

An excellent account of the habits of *Cambarus pellucidus* (Tellk.), with description of the subspecies *testii*. Also remarks on Shiloh and Mayfield's caves.

Hovey, Rev. H. C.—"Celebrated American Caverns, especially Mammoth, Wyandotte and Luray," 1882.

Mentions briefly several of the caves in Lawrence County, and gives an extended popular account of Wyandotte, accompanied by maps and illustrations.

Mercer, H. C.—Am. Nat., 1894, 1,065.

Mercer, H. C.—"Jasper and Stalagmite Quarried by Indians in Wyandotte Cave." Proc. Amer. Phil. Soc., XXXIV, 1895, 396.

In these two papers Mr. Mercer states his doubts of the alleged age, as given by Hovey, of the stalagmite quarry near the base of the "Pillar of the Constitution" in Wyandotte. In the second paper he describes briefly the quarry and mentions other discoveries made by him, which tend to prove the Indians' former inhabitancy of Wyandotte.

Owen, Richard.—Ind. Geol. Surv., 1859–'60, 149. Gives a four-page description of Wyandotte, accompanied by two illustrations and a good map, the latter in appendix to the volume.

Packard, A. S., Jr.—"The Invertebrate Cave Fauna of Kentucky and Adjoining States." Am. Nat., IX, 1875, 274. Mentions the habits of *Linyphia subterranea*, a small spider found in Wyandotte, also comments on the origin of the myriapod therein found.

PACKARD, A. S., JR.—"The Cave Fauna of North America with Remarks on the Anatomy of the Brain and Origin of the Blind Species." Mem. Nat. Acad. Sci., IV, 1888. Treats in detail the fauna of Wyandotte and Bradford caves; gives brief description of Clifty Caves, Washington County. Gives full descriptions of many cave animals, with notes on origin, changes due to environment, etc. The most valuable work extant on cave fauna.

PACKARD, A. S., JR.—"The Effect of Cave Life on Animals." Popular Science Monthly, XXXVI, 1890, 389. Discusses the origin and changes due to environment of certain animals found in Bradford and Wyandotte caves.

PUTNAM, F. W.—"The Blind Fishes of Mammoth Cave and Their Allies." Am. Nat., VI, 1872, 6. Mentions the occurrence of *Amblyopsis spelæus* in Wyandotte Cave and Lost River, Indiana. Discusses its origin and habits, and the changes which it has undergone by cave environment.

STELLE, JAS. PARISH—"The Wyandotte Cave of Crawford County, Ind.," 1864. A 12mo. volume of 85 pages, giving a good popular description of the cave. The distances, however, are very much exaggerated.

A REPORT

ON THE

Geology of the Middle and Upper Silurian Rocks

OF CLARK, JEFFERSON, RIPLEY, JENNINGS AND SOUTHERN DECATUR COUNTIES, IND.

BY AUGUST F. FOERSTE.

GENERAL INTRODUCTION.

The rocks of Indiana occur in layers or beds which may often be traced for many miles. While they vary considerably in thickness at distant points, they often preserve nearly the same thickness for several miles, and if followed only a few hundred feet, show no appreciable difference as regards thickness. Along deep valleys the same layer or sheet of rock may be traced along one side of the valley to a point where it forms part of the bed rock of some stream, and then it may be followed along the other side of the valley back again to a point opposite that from which the investigator started. After several observations of this nature it will not be difficult to arrive at the conclusion that the same layer once extended entirely across the valley; in other words, that there was a time when the valley did not exist and when the layer of rock was continuous. The valley was formed at a later time by the erosive action of some creek or stream. How streams manage to wash out valleys in rocky countries, leaving originally continuous sheets more or less separated, has often been carefully investigated, and subjects of this kind had better be studied after reading some one of the more popular books on geology. It will then be discovered that, originally, continuous layers of rock, not only once extended across the gap now formed by valleys, but also reached the now isolated and distant hills. In other words, the same layer of rock once extended for many miles in a continuous sheet over parts of the country now broken up by valleys and hills. At that time there were no valleys and hills, such as we now see in these districts. The valleys were formed later, and when, in the course of time, the rock in certain places was weathered away, and the broken up material was washed away by streams and rains, wherever a part of the rock remained standing, a hill was left behind, and wherever the depression between the hills was deep enough, a valley was formed. Hills and valleys are therefore cut out from once level stretches of land.

While the same layer of rock often preserves the same color, grain and chemical character for many miles, it is very common to find a certain amount of variation between the different layers exposed at any one locality. Sometimes the layers overlying each other may present essentially the same characteristics. For instance, in the quarries at New Point, Osgood and Harris City, from ten to twenty layers of rock are all of a white color, have a very fine grain and very nearly the same chemical composition. The layers differ only in thickness. A group of layers of this kind may be classed together and given a separate name. In the case just cited, the name Laurel limestone is used for these beds. About 10 or 15 feet below the base of these white limestones is found a salmon-brown limestone bed varying usually from 1½ to 3½ feet in thickness. It is coarser grained, and, as the color would indicate, has a somewhat different chemical character. This rock is called the Clinton. The space between the Laurel bed and the Clinton is composed of a number of layers of material which differ considerably from each other. Some of the layers consist of limestone, most of them of clay, a part of the clay often forming a fairly hard rock. Each of the different layers could be given a separate name, but it is more practical to class the various layers, between the Laurel and Clinton layers, together and apply to them the single name, Osgood beds. Beneath the Clinton layer at Madison is the banded, brown and blue rock which forms the steep walls at the side of the Michigan and Telegraph roads, and at many of the waterfalls for miles around. Here, the layers for a vertical distance of 40 to 55 feet present essentially the same color, grain and chemical composition. These layers are grouped under the name Madison beds. Farther down there is a great mass of rock, consisting of thin layers of limestone and thin layers of clay or shale, alternating in a very irregular fashion and yet preserving essentially the same general features. Rocks of this nature extend down for nearly 300 feet, as far as low water mark on the Ohio River. One name could be given to this entire series, notwithstanding its great thickness. In this report they are called the fossiliferous limestones below the Madison beds. As a matter of fact geologists use a name for these rocks which includes also the beds which we have just called the Madison beds. This name, used for both, is the Cincinnati Group. In the same manner the Osgood beds, the Laurel limestone and a considerable thickness of rock overlying the latter (the Waldron shale and Louisville limestone) have been classed together and form the larger associated series of rocks called the Niagara Group.

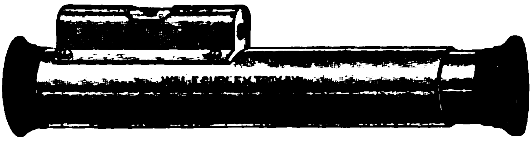
The various groups, large or small, present differences which can be readily recognized by persons who make rocks a study. Persons who have but moderate experience in the study of rock usually succeed in recognizing very readily the more characteristic groups in their own section of the country. In fact, groups can be recognized more readily than particular layers.

The same group presents essentially the same appearance for many miles, but the different groups may of course vary considerably from each other. If a person learns to distinguish the different groups as they are exposed along some hillside, and remembers their order of succession, he is in a much better position to recognize the fact that the same rocks must once have extended across valleys, and from hill to hill, that they must once have formed vast continuous sheets, not as yet broken up by valleys and hills. For, isolated hills will present the same groups of rocks with the same thickness, with the same order of succession and at the same level as the more continuous stretches of land, one or two miles, sometimes many miles, away.

While the different groups of rock can usually be readily recognized by means of differences in color, grain and chemical composition, they can be still more readily distinguished by means of their fossils. If, for instance, the fossils found in the Cincinnati, Clinton and Niagara groups be compared, scarcely a fossil found in one group will also be found in the other. Moreover, when the Osgood and Waldron beds, both belonging to the same group, are compared, the general type of fossils in each bed is quite distinct and may be easily recognized, although a number of fossils are found at both levels.

This being the case, if a person recognizes one bed or a series of beds of rock, and knows the order of succession of the different groups, he can tell what groups of rocks should be found above, and what groups should be found below the group first examined. It is not necessary to have all the groups exposed. If he remembers the thickness of the different groups he can in a measure predict at what level the other groups will be found in case the earth is removed. For this reason a collection of statistics regarding the various outcrops of rock at different localities becomes valuable not only in order to inform the investigator where certain layers of rock occur but also to enable him to locate other beds of rock by means of the data already discovered. If, for instance, it is desired to learn if the Laurel limestone is present in any locality, it is necessary only to accurately locate the top or bottom of some group of rocks in the immediate vicinity of the area to be investigated. Then, knowing how many feet up or down from this recognized horizon the desired group of rocks should occur, it is necessary only to find a hill high enough or a valley deep enough to expose the same. If the ground is very sloping and is traversed by brooks, go down stream for lower layers of rock and up stream for higher ones.

For work of this kind a pocket level, such as that manufactured by W. & L. E. Gurley of Troy, New York, is very serviceable.



Placing this to the eye, whatever is seen at the same level as the moving bubble of air, is at the same level as the eye, and, therefore, a definite distance above the level of the ground upon which the observer is standing. If a person wishes to ascend 35 feet above a certain point and his eye is five and one-half feet above his shoe sole, he should place himself on the layer of rock which he uses as a mark from which to measure. Whatever object is on the level of his eye is five and one half feet above this layer. Then let him walk to that object, and, standing in this new position find some other point on the same level as his eye. After he has repeated this operation six times, he is 33 feet above the layer of rock from which he began to measure. Two feet above the object last sighted is 35 feet up. By this means it is possible to locate quickly and quite accurately any level above or below any starting point, along a hill slope where the rise or fall of the level is too gradual to admit of less accurate means of determining vertical distance.

3303.

When it is desirable to compare levels at distant points, an aneroid barometer not registering more than 3,000 feet is very serviceable. The pointer will indicate some number of feet at the locality where the observer first stands It will indicate another number at the locality whose relative level he desires to know. If one number be subtracted from the other, the relative difference in level is obtained in feet.

This instrument is sometimes especially made for purposes of surveying, the dial or face of the instrument being made larger. It is, of course, not as accurate as a good level, and is rather expensive. If, however, it be desired to investigate any large area of country, it will be found sufficiently accurate for several miles for most purposes, provided the investigator learn the proper use of the instrument. Books explaining the use of the instrument can be secured from the manufacturers.

Both of these instruments have been used to a considerable extent, in the preparation of this report, in measuring the thickness of the rocks, and in tracing the same layers from exposure to exposure.

THE SUBJECT OF THE REPORT DEFINED.

The following report is an investigation of the Middle Silurian rocks of southern Indiana. It includes, incidentally, also, notes upon the upper layers of Silurian rock. The Silurian rocks of Indiana are divided into two great divisions—the Lower and Upper Silurian. Only the upper portion of the Lower Silurian rocks are exposed in Indiana. The lowest division here investigated was the gasteropod layer, which, although 140 feet beneath the top of the Lower Silurian, is still many hundred feet above the bottom of this set of rocks, the base of the Lower Silurian being found far below the level of the oldest rocks in the State. Little attention is paid to the richly fossiliferous shales and limestones which extend from the gasteropod layer up to within 60–40 feet of the top of the Lower Silurian. Considerable more attention is given to the Madison beds, which are 40–55 feet thick, and which form the upper part of those Lower Silurian rocks which are exposed in Indiana. The Upper Silurian, receiving the most attention in the body of this report, includes the following strata, going upward: The Clinton, never more than five feet thick; the Osgood beds, 15–25 feet thick; the Laurel limestone, 35–45 feet thick; the Waldron shale, 5–10 feet thick, and the Louisville limestone, 40–55 feet thick.

The following section will express in brief form the relationship between the different rocks:

UPPER SILURIAN.	Niagara Group....	Louisville limestone or Utica lime rock.
		Waldron shale.
		Laurel limestone or Cliff Rock.
		Osgood or Cystidean beds, divided in places into the *a.* Upper Osgood clay. *b.* Osgood limestone. *c.* Lower Osgood clay.
	Clinton Group	Clinton limestone.

LOWER SILURIAN.	Cincinnati Group..	Madison beds and their northern equivalents. Overlying the typical Madison beds are the *Murchisonia hammelli* beds and the terminal white limestone layer.
		The richly fossiliferous shales and limestones below the Madison beds. The equivalents of the Madison beds northward present the same characteristics as these lower beds.
		The gasteropod or Marble Hill bed.
		A great section below not studied.

A number of the minor subdivisions are here named and defined for the first time. The names are taken from localities near which typical exposures may be found.

The Louisville limestone is named after the fine exposures of this limestone east of Louisville, which have furnished most of the fossils cited from the Louisville Niagara. The fossils have been redescribed and figured recently by Nettleroth in the publications of the Kentucky survey. The Waldron shale is named after the exposure at Waldron, in Shelby County, Indiana. The fossils of this group were described and figured by Hall in the publications of the Indiana survey. The Laurel limestone is named after Laurel, in Franklin County, Indiana, in the vicinity of which town there are many small quarries. The Osgood beds are named after Osgood, in the vicinity of which town the upper part of this formation has furnished many fossils. The fossils of this group still await study. The large number of species of cystideans described by S. A. Miller in the various publications of Indiana, Illinois and elsewhere, are derived from this formation in southeastern Indiana The divisions of the Osgood beds into upper and lower clays and the intermediate limestone bed, are typically exposed at localities 58 and 75, in northern Jefferson County. The Clinton limestone is the continuation of a limestone bed found in Ohio and identified as the Clinton by Prof. E. Orton and others. The name has been retained for the western extension of this formation. The fossils of this formation have been described and figured by Foerste in the Ohio reports.

The Madison beds receive their name from Madison, in Jefferson County, Indiana. Although the name Madison has already been once used to designate the Lower Silurian rocks exposed at Madison, it has never been adopted, and the prior name, Cincinnati group, is the only one ever used for these rocks even in Indiana, therefore the name is practically free to designate a much more special group of rocks at the very top of the Lower Silurian typically developed at Madison and in the more immediate vicinity. The typical Madison beds are scantily fossiliferous and contain only the ordinary Cincinnati group fauna. A few of the fossils of the *Murchisonia hammelli* beds, above the typical Madison, have been described by S. A. Miller in publications of the Indiana survey and elsewhere. The general Cincinnati group fauna has been described in the publications of many surveys in addition to those of Ohio and Kentucky.

Very few persons probably have a conception of the monetary value of a good collection of fossils. The collection made by Prof. Hall, of New York, in the vicinity of Waldron, was worth several tens of thousands of dollars. The specimens of Holocystites and other cystideans found in the Osgood bed bring a good price if well preserved. Even the very common Cincinnati group fossils, if well preserved, find a ready sale. It is rather surprising that persons of large means have not undertaken the *systematic* exploration of fossil beds for the purpose of supplying college cabinets and museums with comparatively full sets of fossils of different formations at fairly reasonable prices. Indiana possesses several horizons which could be well exploited.

In the following pages are described, first, the various principal groups or beds of rocks, as indicated in the preceding section, and next, the various localities visited which present features of interest. The careful description of these localities certainly ought to serve as a good basis from which to determine the location of other desirable rock. At the close of the report will be found a few suggestions regarding the more valuable formations found in the area investigated.

DESCRIPTION OF THE VARIOUS FORMATIONS STUDIED.

THE GASTEROPOD LAYER.

At Marble Hill, near the southern border of Jefferson County, there is a stratum of Lower Silurian rock, about 140 feet below the Clinton, or 80 feet below the Madison bed, which is full of gasteropod remains. The stone is of a white color, and the presence of the gasteropod shells promised to give the stone superior commercial value. It was found, however, that the stone would readily disintegrate under the influences of weathering, and the quarry has therefore been abandoned. This gasteropod layer occurs also five miles southwestward, at locality fifteen, 133 feet below the Clinton; three and a half miles northwest (22),* about 120 feet below the Clinton; four miles northward (25), 147 feet below the Clinton; and four and a half miles northward (26), 133 feet below the Clinton. The most distant points are nine miles apart.

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*The numbers refer to the localities on the maps which accompany this report.

FOSSILIFEROUS LIMESTONES BENEATH THE MADISON BEDS.

Below the gasteropod layer, and also above the latter, the lower Silurian consists chiefly of interbedded layers of limestone and clay, both being often abundantly fossiliferous. In some regions these richly fossiliferous limestone and clay beds terminate quite abruptly 40 to 60 feet beneath the Clinton, and are overlaid by a very argillaceous rock, or very impure limestone, which is described in the next section under the name of the Madison bed.

The top of the richly fossiliferous, thin limestones is found possibly 40 feet below the Clinton at locality 6; 34 feet below at 7; 46 feet at 12; 40 feet at 14; 38 feet at 15; 61 feet at 18; over 54 feet at 22; 32 feet at 23; 67 feet at 25; 47 feet at 26; 49 feet at 33; about 60 feet at 34; 40 feet at 37; 63 feet at 40; at 50 feet at 41; 34 feet or more at 42; 58 feet at 46, and 38 feet at 57.

Where the Madison beds are not present, thin fossiliferous limestones and clays are found at much higher altitudes, even as far up as the base of the Clinton. The measurements above given have significance, therefore, only in regions where the Madison phase, at the top of the Lower Silurian, occurs.

THE MADISON BEDS.

In the vicinity of Madison, the top of the Lower Silurian is formed by a considerable thickness of argillaceous limestones, weathering on long exposure from light brown, more or less banded with darker brown, to even purplish tinted layers. Although not entirely unfossiliferous, the fossils in these argillaceous limestones are confined to a few layers, and by far the greater part of the layers are without fossil remains. Beneath the banded limestones occur eight feet of the *Favistella* bed, which near Madison seems to form a well marked horizon. The banded limestones are inclined to form vertical walls, owing to their massive character, and owing to the wearing away of the softer shales and clays at their base. This is especially true along the beds of streams, so that the banded limestones often form steep walls, over which plunge the many picturesque falls of Jefferson and Clark Counties. The banded limestones have a thickness of 30 to 32 feet in the vicinity of Madison, and together with the underlying softer shales and the included *Favistella* beds of the latter, constitute a well marked horizon in Jefferson and Clark Counties.

The most southern exposure of the Madison bed, showing all the characters typical of this rock, is along Lick Run, southeast of Charlestown (6), where it seems to be 40 feet thick. It unquestionably has a still greater southern and western extension. At locality 7 the characteristic Madison bed is only 16 feet thick, but is underlaid by 13 feet of beds, some of the layers containing a few fossils, and by five feet of clay, which corresponds to the base of this horizon elsewhere. At 12 it is 46 feet thick; at 14, 47 feet; at 15, 34 feet; at 18, 48 feet; at 22, 54 feet; at 23, 30 feet; at 25, 65 feet; at 26, 45 feet; at 29, the upper 20 feet of the Madison bed are harder, and project over the softer Madison beds beneath; at 33 they are 37 feet thick; at 34, 60 feet; at 37, the typical Madison bed, 30 feet thick, is underlaid by about eight feet of shaly material, forming the base of this horizon; at 38 a similar exposure occurs; at 40 the typical Madison bed, 35 feet thick, is underlaid by a considerable thickness of shales, certainly more than 12 feet; at 41 the typical Madison, 30 feet thick, is underlaid by at least 17 feet of shaly material; at 42 the typical Madison, 34 feet thick, is underlaid by the more shaly beds, which here contain fucoidal markings; at 46 the typical Madison, 40 feet thick, is underlaid by 18 feet of clayey shale with fucoidal markings.

At 55, the upper part of the Madison bed changes to a soft, whitish limestone; at 57, the upper part of the Madison changes also to a considerable extent into a soft, whitish limestone, 20 feet of this phase being underlaid by 15 feet of typical Madison stone. At 60, the Madison bed is underlaid by shaly courses containing *Favistella* below. The shale phase at the base of the Madison bed occurs, according to the preceding notes, chiefly in the vicinity of Madison and northeastward. The Madison occurs at all points southwest of Madison in Jefferson and Clark Counties. North of Madison it occurs in typical form as far as 36, 40, 41, and points northeastward; east of Madison all the exposures show the Madison bed.

The Madison bed seems to have approximately the same distribution as the fine-grained, light brown or reddish brown, more sandy Clinton to be described later, but it extends farther westward than that phase of the Clinton at almost all points, except in the northern part of Jefferson County. This similar distribution of the Madison bed, and of the sandy phase of the Clinton, unquestionably is due to a similar physical history.

The Madison bed not infrequently includes thin layers of limestone enclosing a few fossils of Lower Silurian age, chiefly *Orthis occidentalis* and various bryozoans. These layers are never frequent at any one locality, and are often entirely absent. They are especially likely to occur near the base of the typical Madison beds, and at their very summit. In the shaly courses below the typical Madison beds *Favistella stellata* is a not uncommon fossil. It usually occupies one or two layers about 8 to 15 feet below the typical Madison bed. It occurs at 33, 37, 38, 40, 41 and 60.

The typical Madison bed is commonly overlaid by other rock, the Clinton being found several feet higher up. This intervening rock is commonly a bluish, fine-grained limestone, with fossils, and of no commercial value. Sometimes it is an ordinary blue limestone, containing fossils chiefly along the partings between the different layers. *Murchisonia hammelli*, *Holopea hubbardi*, a small species of *Orthoceras*, *Leperditia cæcigena* and other fossils are especially characteristic of this horizon. One or more of these species are found at localities 14, 23, 25, 26, 28, 37, 38, 39, 40, 42, 55, 56, 57, 70 and 84. These beds might be called the *Murchisonia hammelli* beds. They vary from a few inches to five feet in thickness. Large masses of Labechia are not uncommon fossils in the clay layers which occur at various levels in these upper limestones; they are found at localities 15, 23, 25, 26, 29, 30, 31, 37, 40, 42, 55 and 56. *Tetradium minor* is found at the top of the Lower Silurian at 14. Both *Labechia* and *Tetradium* continue to be exposed at or near the top of the Lower Silurian in the exposures farther northward beyond the region occupied by the typical Madison phase of the Lower Silurian or the overlying *Murchisonia hammelli* bed.

The very top of the Lower Silurian, in the neighborhood of Charlestown, at localities 1 and 7, is formed of a fine-grained white, hard limestone four to six inches thick. At 13 and 18 the top of the Lower Silurian is a sandy limestone, 80 to 84 inches thick, and difficult to distinguish from the overlying Clinton. From the vicinity of Hanover (28) to Clifty Falls (36) and northeastward (49, 56, 57) the top of the Lower Silurian is often formed by a bluish limestone layer four to 10 inches thick and often containing *Leperditia cæcigena.* This layer is much better developed in Ripley and Jennings Counties, where it furnishes the material for the pebbles in the Clinton. It there, however, rarely contains *Leperditia*

NORTHERN EQUIVALENTS OF THE MADISON BED.

North and northwest from the typical Madison bed, the top of the Lower Silurian rapidly changes its character. It is replaced by a series of blue, often rather dark blue, very fine grained limestone. This limestone where quarried often seems to be very solid, but it will not withstand weather. Where long exposed in the banks of streams it is traversed in many directions by close, minute cracks, along which the rock is often discolored to an iron-stained brown or even a purplish color. The rock often contains *Leperditia cæcigena*, *Isochilina subnodosa.* Lithologically, this rock is similar to the dark blue, fine grained layer forming part of the *Murchisonia hammelli* layer in more southern areas. The first change of the Madison beds northwards consists in fact in the alteration of the Madison beds, so as to present the same lithological characteristics as the blue beds which southward, near Madison, only overlie the Madison beds. The fine-grained dark blue limestone, taking the place of the

Madison beds, is interbedded with ordinary limestones, and with clays containing ordinary limestone fossils. Sections of this type begin to be exposed in northern Jefferson County, and are typically developed at Versailles, along the whole length of Big Graham Creek, and for some distance northwards. The correspondence of this section is very well seen in the exposure immediately north of Versailles, where 29 feet of this limestone, with its intercalated beds of clay and shale, are underlaid by 11 feet of unfossiliferous brownish and bluish shales, corresponding to the shales at the base of the Madison beds near Madison. Below the shales are 12 feet of limestone and shale, containing *Tetradium minor* at many levels, and *Favistella stellata* at the very base. This is the characteristic horizon for *Favistella* in southern Indiana. The shale bed of the preceding section is exposed also at locality 109.

From the Baltimore & Ohio Southwestern Railroad northwards, all comparison with the Madison beds is lost. The upper strata consist commonly of thin or shaly limestones, interbedded with clays, both usually abundantly fossiliferous. No demarcation can be made between these upper strata and the lower horizons of the Lower Silurian, corresponding to the separation of the Madison from the richly fossiliferous shales in southern Jefferson and in Clark Counties. This means that the Madison beds are replaced northwestward by limestones, just as the sandy Clinton is replaced northwestward by pure limestones.

TERMINAL LOWER SILURIAN WHITE LIMESTONE.

At many points in Ripley, Jennings and Decatur Counties, the upper part of the Lower Silurian is terminated by a white, fine-grained limestone, which immediately underlies the Clinton and which has furnished the material for the pebbles inclosed in the latter. In many places it closely resembles lithologically some phases of the Laurel bed, although it is usually a softer stone. It occurs at localities 102, 107, 110, 111, 114, 116, at New Point, 123, 125, 126, 130, 133, 134, 135, 138, 142, 146, 148, 161, 162, 163, 164, 165, 170, 178, 179, 181, 182, 183 and 193. This limestone varies usually from 4 to 8 inches in thickness, but occasionally reaches from 12 to 15, and in one case 48 inches in thickness. In the northwestern part of Ripley County, the northeastern part of Jennings County, and the adjacent parts of Decatur County this white limestone often contains fossils, especially *Strophomena alternata.*

At several localities this layer of white limestone is penetrated by worm burrows, which have been filled in again with detrital material, whose salmon-yellow color suggests that these burrows were made by animals during Clinton times. Such burrows exist at 110 and 146, for instance. At 135 the top of the white limestone shows cracks of the type usually called sun cracks. The salmon-brown Clinton resting upon this limestone has filled in all of the cracks.

OÖLITIC CONCRETIONS.

The thicker layers of limestone in the upper part of the Lower Silurian from Osgood to Nebraska, and northward as far as the Decatur County line, frequently contains oölitic concretions of large size, often a quarter of an inch in diameter. The concretions frequently enclose fragments of Lower Silurian fossils, especially fragments of brachiopods and pieces of branching bryozoans. Their geographical distribution is about the same as that of the pebbles which occur in the Clinton.

CLINTON.

The greatest recorded thickness for the Clinton in Clark County is 32 inches or two and two-thirds feet. At no point is it known with certainty to be entirely absent. Where this appears to be the case, near Charlestown Landing, the apparent absence is due to a peculiar horizontal sliding and faulting in the rock, to be described elsewhere. The salmon-brown color, so typical of more northern exposures, is shown only by the most southwestern exposures (1, 5, 7). Even at these localities a large part of the Clinton limestone is of a light red color, only a portion of the rock being of a salmon-brown color. At all the remaining exposures in Clark County the Clinton is of a whitish, light brown, or a light, reddish brown color; the rock is usually fine grained and hard, occasionally becoming coarser grained, and containing crinoidal remains. Recognizable fossils are very rare.

The light brown or reddish brown Clinton rock continues northward into Jefferson County, along the regions nearer the Ohio, to a point about five miles north of the county line. However, the more western exposures in the southwestern corner of Jefferson County, at Dog Falls and westward, and those from Hearts Falls, through Hanover to the horse-trough on the Madison–Hanover pike, have the typical salmon-brown color. The salmon-brown Clinton continues to be exposed from the northern branches of Crooked Creek, and from the southern end of Hall's Ridge northward beyond the county line. Along the Ohio River near Madison, however, in the area northeast of Madison, and in the northeastern corner of the county, the Clinton is usually a fine grained, light red or reddish brown rock, with few fossils. The salmon-brown Clinton usually contains abundant fossils, although these are usually imbedded in the solid rock.

In Jefferson County the Clinton rarely exceeds 36 inches in thickness, although thicknesses of 45 and 52 inches ($3\frac{3}{4}$—$4\frac{1}{3}$ feet) are reached. At no point is it known to be entirely absent.

The siliceous, light red or reddish brown, fine grained form of the Clinton continues from the northeastern corner of Jefferson County northward into Ripley County, toward Olean. The salmon-brown, coarser-grained Clinton occurs farther westward.

Sufficient data are not at hand to enable any one to discuss with confidence the areal distribution of the two lithological types of Clinton in southern Indiana. At present, however, it seems as though the fine-grained, light brown or reddish brown Clinton occupied a great area east of the salmon-brown crinoidal Clinton.

A line connecting localities 1, 5, 7, 23, 24, 27, 28, 29, 30, 31, 33, 34, 40, 41, 52, 53, 62, 63, 68, 82, 89, 90 and 94 will indicate in a general way the eastern outcrops of the salmon-brown Clinton. West of this line the Clinton is of a salmon-brown color and is coarser-grained. East of this line the Clinton has a more light reddish brown color, is fine-grained, and possesses more sandy material and less lime. The salmon-brown Clinton near the eastern border of its area of distribution frequently contains lenses of a white, fine-grained rock. This rock occasionally forms continuous sheets for several feet, but usually occurs only in small patches, evidently once continuous. The forces which removed the intermediate parts have occasionally broken up these sheets more roughly and left the fragments in a more angular form in the salmon-brown Clinton. These, then, must not be confounded with the pebbles of Lower Silurian origin which are often found inclosed in the Clinton in various parts of Ripley County. The pebbles of Lower Silurian origin are usually derived from a still more fine-grained, very dense, white limestone, which is the terminal Lower Silurian white limestone or a layer at the top of the Lower Silurian, parts of which are often still preserved *in situ* in southern Indiana. Pebbles derived from this limestone are found at several localities two and three miles west of Cross Plains (88, 89, 90).

With the exception of the small area in the southeastern part of Ripley County, south of Olean, the Clinton formation of Ripley, Jennings and Decatur Counties has the salmon-brown color typical of the Clinton in southern Indiana. The greatest thickness of Clinton limestone recorded in Ripley County is 64 inches or 5⅓ feet, in Jennings County is 11 inches, and in southern Decatur County, south of the Big Four Railroad, is 28 inches. From these measurements the thickness of the Clinton decreases to nothing, so that the Clinton is absent at some points in all three of these counties.

In this case it is again difficult to define with certainty the area over which the Clinton is absent. The most eastern and northern outcrops where it is absent are 130, 131, 152, 153, 159, 180, 164, 178, 190 and 191. East and north of this line the Clinton has been found present in all the sections actually examined, although it is often only 15 inches or less in thickness. West of this line the Clinton is almost everywhere absent. Local patches of Clinton, however, are found in places within the area where it is usually absent. Clinton 11 inches thick is found, for instance, in Jennings County, at locality 182; Clinton 4–10 inches thick, including pebbles of dense white Lower Silurian limestone, occurs at 174; Clinton 2–3 inches thick, including pebbles, is found also at 167. The geographical extent of these Clinton patches in the general Clinton-less area seems to be small. The southern border of the area within which the Clinton is absent is still more difficult to define. The border seems to be very irregular, and to cross the Big Graham several times. The Clinton is absent at localities 130, 131, 132, 138, 140, 136 and 166. It is only one inch thick, and contains Lower Silurian pebbles at 137 and 165. It is present, however, and varies from 6 to 22 inches at 133, 139, 135 and 134. This last patch of Clinton is probably connected with the main body of Clinton southward and eastward. The western extent of the area in which the Clinton is absent is, of course, unknown.

The Clinton-less area was unquestionably either above water or covered only by very shallow depths of the sea during a part or the whole of the Clinton period. Around its margin, as might be expected, pebbles composed of the upper layers of Lower Silurian rock are very common. Such Such pebbles are found, for instance, at 165, 137, 135, 134, 133, 139, 129, 127, 128, 126, 125, 124, 123, 100, 143, 142, 102, 105, 106, 107, 149 and 162. The frequency of these pebbles in the region east of the area where the Clinton is altogether absent suggests that even these regions may at times have been above water, or have been at least covered only by shallow waters during the earlier part of the Clinton period.

The following condensation of the previous observations may be of value: The Clinton of southern Indiana is usually a salmon-brown, rather coarse-grained limestone. In the southeastern parts of Clark, Jefferson and Ripley Counties, however, roughly between Charlestown Landing and Olean and southeastward, the Clinton is replaced by a more sandy, finer grained, light brown, or reddish brown, limestone. In those parts of Ripley, Decatur and Jennings Counties lying west of a line connecting New Marion and Millhousen the Clinton is usually absent, and was once above the sea, or at least under very shallow water.

BASAL NIAGARA LIMESTONE.

The *basal Niagara limestone* has been recorded as existing in Clark County at only one locality, 8, opposite the mouth of Collins Run. It was not especially looked for, and may have escaped attention. In the southwestern portion of Jefferson County it is a white limestone, often rather soft, varying from 8 to 15 inches, sometimes to 22 and even 32 inches in thickness. In the vicinity of Madison, at Hanging Rock, along the Madison pike, on the pike to Manville, and in Lonesome Hollow the salmon-brown Clinton is overlaid by a light brown, siliceous limestone, on which rests a gray limestone. The latter has been called the basal Niagara limestone, and the former has been considered a transition rock between the Clinton and the Niagara. The total thickness of these layers usually varies between 16 and 24 inches. Between the localities in the vicinity of Madison, just mentioned, and the northern boundary of Jefferson County, the basal Niagara limestone usually varies between six and eight inches.

In Ripley County, near the head branches of the east fork of Indian-kentuck Creek, it is a siliceous, reddish-brown limestone about 10 inches thick. Near New Marion and westward the basal limestone varies from 8 to 11 inches. Near the county line on the Big Graham it is reduced to three inches. On the Big Otter Creek, near the county line, it is 12 to 15 inches thick. In the northwestern angle of Napoleon and north of Napoleon it is reduced to two to four inches in thickness. In Jennings County there is an increase to 16 inches at the most westerly exposure on the Big Graham, while the most western exposure on Otter Creek, shows a thickness of only two to three inches. Variable thicknesses are also shown northwards. In Decatur County, on upper Sand Creek and Cobb's Fork, it measures two to four inches. East of Westport it is about 15 inches thick.

While the basal Niagara limestone is not found in all localities, it has a very wide distribution, a comparatively uniform thickness, presents very constant lithological characteristics, and is almost always present when the Clinton is absent. It is rarely fossiliferous, but occasionally becomes crinoidal and may even contain well-preserved fossils.

At one locality in Ripley County, on Big Otter Creek (152), a Clinton pebble was found inclosed in the basal Niagara limestone. The limestone at this place was very fine grained. It is the only instance of a pebble occurring in the basal Niagara so far noted. Nothing of the kind has been seen in corresponding rocks in Ohio.

LOWER OSGOOD CLAY.

Above the basal Niagara limestone, or, when that is absent, directly on the Clinton limestone, is found a bed of clay or of clayey shale, varying locally to an argillaceous limestone, or even to thin layers of rubbly limestone. It is here called the *Lower Osgood Clay Bed.* In Clark County it is usually a blue, clayey shale, about 11 feet thick. In Jefferson County it is a blue or light brown clay or clayey shale; sometimes it varies to a hard, indurated clay rock, and rarely into an impure limestone. Southwest of Madison it varies from 8 to 10 feet in thickness; east and northeast of Madison it often reaches 14 and 15 feet in thickness. In the southern part of Ripley County it varies between 11 and 16 feet. Along Big Graham it is 6 to 8 feet thick. East of New Marion it is a clayey shale; west of New Marion it is a clay bed.

From Osgood, along the most southern tributaries of Big Otter Creek to the western part of the county, and thence northward to the northern end of the county, the Lower Osgood clay is no longer a uniform clay bed. It changes its character, the lower half remaining a soft clay or a clayey shale, while the upper half turns into a rubbly limestone. The transition is not a sudden one. The upper half of the Lower Osgood clay becomes a somewhat harder, indurated clay rock, along Big Creek, in Jefferson County. Farther north it occasionally shows similar features. Farther north, along Otter Creek, it becomes a clay rock containing irregular masses of limestone, and still farther north it is often a rubbly limestone; *i. e.*, a limestone with very irregular surfaces easily breaking up into irregular fragments, occurring in thin layers, usually varying between two and three inches in thickness.

This change of the upper half of the Lower Osgood clay bed into a rubbly limestone is accompanied by an alteration of the lower half into a harder indurated clay rock, which often looks so much like the Madison beds at the top of the Lower Silurian, that they would be taken for the latter were it not for their occurrence *above* the Clinton limestone. When it assumes this appearance it is often called the Madison-like clay bed in the body of this report. Along the upper tributaries of Big Otter Creek, the indurated lower clay, overlaid by the rubble limestone, have a total thickness of seven feet. Near the county line and on Brush Creek they are 9 to 12 feet thick. On the head waters of the Muscatatuck they are seven to nine feet thick. North of Napoleon they are reduced to 3 and 3½ feet, but at New Point they are again seven feet thick. In Jennings County, along Otter Creek, they vary from 9 to 11 feet. Along the Muscatatuck and its various branches they usually measure from 7 to 10 feet in thickness. In some of the more northern exposures the upper half of the Lower Osgood clay does not present its usual rubble limestone characteristics. Instead of this, the limestone is occasionally an even bedded, fine grained but soft limestone. It takes this form also in Decatur County, along Squaw Creek, also on Sand Creek and its various tributaries.

Very often the rubbly limestone is decidedly crinoidal, and it occasionally shows very well preserved fossils.

THE OSGOOD LIMESTONE.

Above the Lower Osgood clay bed or its equivalents (the indurated clay bed, overlaid by the thin rubble limestones), there is almost everywhere a layer or a number of layers of limestone, very crinoidal in character, and usually presenting fossils on its upper surface and in the intercalated, thin clay beds.

This limestone occurs in the various exposures southeast of Charlestown, in Clark County. Along the head waters of Bull Creek and Camp Creek five feet of limestone belong to this horizon. The same thickness is shown at Marble Hill, in Jefferson County. At Clifty Falls, and from Madison eastward and northward, the limestone varies usually from three to four feet in thickness. Along Big Creek and in the southern part of Ripley County, a clay layer is usually found near the middle of several limestone beds occupying the Osgood limestone horizon. Along the Big Graham it is three feet thick. Along Big Otter Creek and its tributaries it is only one to one and one-fourth feet thick. It is also thin in the northern part of the oounty. Near Osgood, however, it is about 30 inches thick and is quarried for lime. The plaster made of this lime is said, however, to get very brittle after it has become old.

UPPER OSGOOD CLAY.

Overlying the Osgood limestone, in most of the localities investigated, is a thin clay bed. The most southern exposures recorded are on the head waters of Bull Creek, where it is represented by the shale varying from two to five feet in thickness. Near Kelly's mill, on Camp Creek (16), it is a blackish, clayey shale, three feet thick, containing a few limestone lenses and some crinoidal remains. In Jefferson County this upper Osgood clay is typically exposed in the vicinity of Madison, and thence northward, varying from three to five feet in thickness In southern Ripley County and along the Big Graham it varies from four to five feet in thickness. Further northward the clay rarely exceeds one foot in thickness. It is often reduced to a few inches, and since the underlying Osgood limestone in the same area is also greatly reduced in thickness, these upper Osgood beds are difficult to distinguish from the lower Laurel limestone beds, when the latter also contains intercalated clay beds or are not typical lithologically. In Jennings County the upper Osgood clay is two to three and one-half feet thick on the Big Graham, and locally on Otter Creek and on Muscatatuck Creek near the mouth of Brush Creek. Elsewhere and also northward it is reduced in thickness, as is the case in Ripley County. When this is the case, the Osgood limestone and the base of the Laurel limestone are often very similar.

THE LAUREL LIMESTONE.

Overlying the more variable Osgood beds is a series of limestones presenting quite constant lithological features over considerable areas. It is well exposed in numerous quarries in the vicinity of Laurel, in Franklin County, whence the name. It usually is a very white, hard limestone, occurring in even layers, from four to 16 inches in thickness, which can be readily obtained in slabs of almost any desirable dimensions, forming a very valuable building rock. In Ohio it is known as the Dayton limestone. In Indiana it occurs, and is frequently quarried, in Wayne, Fayette, Franklin, Rush, Decatur, Ripley and Jennings Counties. The most southern localities where the typical rock is quarried to any extent are southwest of Versailles, at the Adam Caplinger (west of 123) and Tanglewood Church quarries; near New Marion (131, 132), in Ripley County; south of Nebraska (167), south of Butlerville (170), on Otter Creek, at San Jacinto, on the Big Graham, in Jennings County; and at the Reuben Walker bridge, two miles east of Dupont, in northwestern Jefferson County. Many good quarries could be opened along Big Creek east of the last locality. Good stone is exposed between Bryantsburg and Bellview, on tributaries of the west fork of Indiankentuck Creek (57), a mile and a half west of Canaan (59), and elsewhere.

South of Big Creek the Laurel limestone rapidly deteriorates in value, owing to the thinness of the courses into which it divides. Most of the courses do not exceed four to six inches in thickness on surface exposure, although it is possible that farther in the hillside some of the layers would be fairly well united. In the southern part of Jefferson County, along the Ohio River, the name *Cliff rock* is very appropriate, since the Laurel limestone usually forms the cliffs, projecting over the softer Osgood and Lower Silurian beds.

In southern Jefferson County the Laurel formation deteriorates not only in the thickness of the layers which can be quarried, but also in the quality of the stone. The rock is less pure, and becomes a softer, more argillaceous limestone. The result is that the Laurel limestone is not much quarried along the Ohio River as a building stone.

In northeastern Clark County, along Camp Creek (16), the limestone is fairly soft and argillaceous, and has a light brown color.

Its argillaceous character increases rapidly southwestward, until, in the neighborhood of Charlestown, along Fourteen-Mile Creek and its tributaries, it becomes a very argillaceous, decidedly brown limestone, which will not withstand the action of weathering. No one, without tracing the stone from place to place, would think of identifying the useless, brown, argillaceous limestone of Fourteen-Mile Creek with the fine, hard, dense, white limestone east of Dupont, along Big Creek and more northern localities.

In the vicinity of Hanover, and for a few miles northward and southward, the top of the Laurel limestone is formed by five to seven feet of white, hard, solid limestone, which can not be quarried with the ease of the typical white Laurel limestone, but which, nevertheless, has been found very serviceable in this neighborhood, where all the other beds are of no value. The new science hall at Hanover College secured its stone from this white limestone ledge at the top of the Laurel limestone formation. The best exposures are found along the new Hanover Landing Road (31), above Butler Falls, at the road corner (29), and at localities 26, 27 and 34.

The Laurel limestone frequently contains chert layers. These are rarely found near the base of the formation in the area here investigated. An exception must be made in case of the exposures near Charlestown Landing and along Fourteen-Mile Creek, where the lower layers of the Laurel bed include chert layers. Since the Laurel beds here, however, have no commercial value, the occurrence of chert layers can cause no damage.

In the vicinity of Hanover, chert layers occur in the white limestone, at the top of the Laurel beds. The white limestone is here a valuable building stone, owing to the inferior character of the lower beds. The chert layers are, however, confined chiefly to the very top of the exposures.

Chert is also found near the top of the Laurel limestone near Canaan (59), at the Tunnel Mill south of Vernon, and elsewhere.

Farther north, where typical white, dense Laurel limestone is extensively quarried, very little chert is found until the quarries near Rossville, north of New Point, are reached. Here chert nodules damage some of the upper layers, and chert layers are found at the very top of the quarry. The chert is found within twelve feet of the base of the Laurel section, although not by any means within that distance of the rock actually quarried, the Osgood beds being also worked.

At Laurel the chert is found within five feet of the base of the Laurel formation.

At Longwood, Ball's quarry contains only the lower four feet of typical Laurel limestone, free from chert layers.

Indeed, from Laurel northward chert layers are commonly found within a few feet of the base of the typical Laurel limestone. It occurs even at New Paris, and at the quarries north of Fair Haven, in Ohio. Owing to the presence of chert only the lower layers of the Laurel formation are very valuable for quarry stone in these more northern regions.

WALDRON SHALE.

The white, fine grained limestone forming the Cliff rock or Laurel limestone is overlaid by a comparatively small thickness of clay or soft clayey shale. In the western part of Jefferson County south of Paris Crossing, in the northwestern part of the county southeast of Dupont, along Big Creek, and in the central part of Jennings County, at the Tunnel Mill, south of Vernon, this clay or clayey shale contains the typical Waldron fauna in sufficient abundance to be readily identified. Clay and clayey shale is found at the same horizon at numerous localities between Hanover, along the Ohio River, in Jefferson County, and Charlestown Landing, in Clark County. The more southern localities are, however, rarely fossiliferous, and even when fossiliferous rarely contain enough characteristic species to make the identification of the horizon of the clay possible upon purely paleontological evidence.

In the southern area here investigated the Waldron shale varies usually between 4 and 10 feet in thickness, although thicknesses of 14 and 20 feet are recorded locally. North of Vernon the fossiliferous Waldron shale is found at Hartsville, in the eastern part of Bartholomew County, and at St. Paul and Waldron, in the southeastern part of Shelby County. In the southern part of Rush County, at Moscow and at Milroy, the equivalent of the Waldron shale is said to contain comparatively few good fossils. In these more northern counties the shales vary from 1–6 feet in thickness.

The most southern locality with an abundant Waldron shale fauna, so far known, lies near Paris Crossing, about fifty miles south of the most northern one. Lithologically, however, the shaly clay can be traced nearly 30 miles farther southward to Charlestown Landing, and similar shaly clay has been recorded from the vicinity of Louisville, so that the Waldron shale may be said to occur in an area at least 90 miles long.

LOUISVILLE LIMESTONE.

The Waldron shale or clay bed is overlaid by an argillaceous or dolomitic limestone. Its usual color is light or medium brown, but where distant from the influences of weathering the brownish layers often show a bluish color. It is an argillaceous limestone. Locally or at certain horizons, however, the limestone is very white and closely resembles the cliff rock. The white limestone is much harder and will withstand the influences of weathering better than the brown layers. The white limestone forms the lower 20 feet of the Louisville limestone beds along the Ohio River front, from Begg's Run (4) to Utica, in Clark County. It is quarried as a building rock at a number of localities and is a very useful stone here, since the white, solid limestone belonging to the Laurel

formation is replaced along the Ohio River front, especially in Clark County, by a much inferior, softer argillaceous limestone. These white Louisville limestone beds are also worked at numerous points between Charlestown Landing and Utica for the manufacture of lime. It is sold extensively under the name Utica lime and is of excellent quality. White limestone is found in the lower half of the Louisville limestone section, also at the Tunnel Mill south of Vernon, in Jefferson County. It is not quarried there, however, since the Corniferous or North Vernon limestones are more satisfactory and are easy of access.

White limestone occurs also at other levels in the Louisville limestone section. Along the pike from Utica to Charlestown is found just below the Corniferous, and is quarried to some extent for building purposes. Except for the manufacture of lime, however, the beds of the Louisville limestone section have only local value.

The thickness of the Louisville limestone section seems to vary considerably. The average thickness is from 40 to 55 feet. Some sections exceed 60 feet, and, locally, sections as low as 25 feet and even 20 feet have been measured.

This may be due to the rapid variation in thickness of the upper Niagara beds, in tracing them from place to place, but it is not unreasonable to suppose that while a clay or clay shale, identified with the Waldron bed, is commonly present at about the same horizon in western Jefferson and in Clark County, this clay bed in different sections appears in reality at slightly different levels, thus giving rise to a considerable variation in the measurements of the thickness of the overlying Louisville limestone beds.

SPECIAL DESCRIPTION OF THE MORE IMPORTANT LOCALITIES.

Clark County.

A. FOURTEEN MILE CREEK AND VICINITY.

The Corniferous is exposed along the Charlestown-Utica turnpike about a mile and a half north of Utica. Its base is 65 feet above the level of the river road at Utica.

Immediately below the Corniferous is exposed the upper portion of the Niagara, which is here a limestone containing frequent fossils. Among these are *Pentamerus nysius var. crassicostatus*, *Strombodes pentagonus*, *Favosites favosus*, *Halysites catenulatus*, *Cladopora and Lyellia.*

The *Corniferous* is exposed on the road leading northwestward from Charlestown Landing, a short distance from the Ohio River. Its base is about 200 feet above the level of the Ohio River.

*1. The *Charlestown lime rock* is quarried by Mr. Stillman on the east side of the road, near the top of the bluff above the Landing. The top of the rock quarried lies 50 feet below the base of the Corniferous. There are at least 17 feet of the lime rock exposed. The stone is whitish in color and contains small crinoidal remains and *Atrypa reticularis.* The general appearance of the rock is very similar to that of the Cliff rock or the Laurel bed in the more northern counties, but is dissimilar to the variety of the Cliff rock exposed at the Landing.

The *Waldron shale* is represented by five to six feet of clay, lying immediately beneath the quarried stone. Associated with this clay in the bed of a branch west of the road are a few thin limestone layers, showing *Caryocrinus* and other fossil remains.

The *Laurel beds*, beneath the clay, are 41 feet thick. They occur in quite regular layers, and where fresh are of a bluish color, though, owing to weathering, the usual color is brown. Along the roadside a few chert layers, five inches thick, occur in the lower part of the series. In the gully immediately west of the road there is a greater number of chert layers present.

The *Osgood clay* is about 18 feet thick. It is a clayey, thin shale, excepting near the base, where a somewhat firmer bed occurs. *Spirifer niagarensis* was the only fossil recognized. It was impossible to distinguish between the upper and the lower clay bed, the intermediate Osgood limestone not being in place.

The *Osgood limestone* was present, however, on the hillside in the form of several large blocks, one of which had a strike of N. 20 W., and dipped 70 W. The limestone had been brecciated and then recemented. It contained *Pisocrinus gemmiformis.* In the gully this limestone is violently folded and brecciated, but does not admit of good stratigraphic measurement.

The *Clinton limestone*, whose stratigraphic position is below the Lower Osgood clay, is present on the hillside, east of the road, in the form of blocks and slabs, lying at various distances from each other in the clayey shale. Their general dip is northeastward. The thickness varies from 20 to 26 inches. Some of the rock has the typical salmon-brown color, but a large part of it varies to a light reddish color, and is very hard. The following fossils were found: *Plectambonites transversalis*, var. *elegantula, Strophomena* (*Orthothetes*) *hanoverensis, Orthis calligramma*, var. *euorthis, Orthis* (*Platystrophia*) *biforata, Camarotœchia scobina, Phœnopora fimbriata, Pachydictya bifurcata, Pachydictya turgida, Heliolites subtubulatus.* In the gully the Clinton is not present.

Associated with the Clinton blocks are fragments of a very fine-grained white limestone dotted with little crystalline segregations two to three mm. in diameter. The fragments are usually four to six inches in thickness, and although at times overlying the Clinton, are known from other sections to belong immediately beneath the Clinton and to represent the top of the Lower Silurian.

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*The numbers refer to numbered localities on the accompanying maps.

The Lower Silurian, immediately beneath the series of Clinton blocks (omitting the fine-grained white limestone), is represented on the eastern side of the road by shaly clay, containing several Lower Silurian species of gasteropods and bryozoans. In the gully west of the road the Lower Silurian is exposed a short distance below the lowest brecciated Osgood limestone exposure. It there consists of layers of hard rock; one of the layers, about five feet below the brecciated Niagara, contains *Orthis* (*Hebertella*) *occidentalis*, and branching bryozoa.

It is evident that the portion of the section from the base of the Laurel bed to the top of the Lower Silurian has been considerably disturbed by geological agencies, so that the section can not be understood without a study of less disturbed regions.

2. Along a small stream entering the Ohio a short distance east of Charlestown Landing, within 50 feet of the river road, the *Osgood limestone* is much brecciated and folded. Several marked faults occur. *Pisocrinus gemmiformis* is found, as usual. The chief axis of folding and faulting seems to be N. 60 W., but the layer is contorted in various directions rather than folded.

3. The base of the *Corniferous* is exposed on the highland southwest of the mouth of Fourteen-Mile Creek.

Five feet below, along a short stream flowing into Fourteen-Mile Creek, the *Niagara* limestone contains *Halysites catenulatus*, *Cladopora* and *Strombodes pentagonus*. Dr. I. Work, of Charlestown, collected at this horizon several specimens of *Pentamerus oblongus*, var. *cylindricus*. Twenty-five feet below the Corniferous the Niagara contains corals, among these the *Strombodes pentagonus* again. Cherty concretions are not uncommon near this horizon.

The top of the *Waldron layer*, here represented by blue clay, is about 55 feet below the level of the Corniferous. The thickness of the clay is nine feet.

The *Laurel bed* or Cliff rock below is practically unfossiliferous. It is composed of layers of hard brownish or bluish rock, with chert layers at many levels, especially in the lower half. At least 70 feet of this rock are exposed without reaching the next underlying rock.

4. A mile and three-quarters northeast of the mouth of Fourteen-Mile Creek, on the land of James Beggs, a little stream known as Beggs' Run enters the Ohio River.

The *Corniferous* is exposed on the top of the hill west of the run.

Twenty feet below the Corniferous the *Charlestown lime rock* has been quarried for building stone. It is 20 feet thick. The broad form of *Pentamerus oblongus* is found.

The underlying (*Waldron shale*) clay is 10 feet thick.

The *Laurel bed* or *Cliff rock* consists, as usual in this part of the country, of brownish courses of an inferior limestone. Its thickness is at least 30 feet.

Beneath are thin courses of a more argillaceous limestone, with a total thickness of 10 feet, representing the *Osgood beds*. The Osgood limestone is not present here.

A hard siliceous layer of reddish brown color, immediately beneath, probably marks the horizon of the *Clinton*.

The eight feet of rock below the Clinton probably represent the upper part of the *Madison* beds. A layer of solid blue limestone at the lower part of this exposure contains *Orthis* (*Hebertella*) *occidentalis*, thus determining definitely its Lower Silurian Age. The Lower Silurian fossiliferous limestone is well exposed in the gully formed by Beggs' Run.

West of the run, on the north side of the road leading from the base of the cliff to the house at its summit, the Cliff, Niagara and associated rocks have been faulted, and the rocks on the southwest shoved over those on the northeast. Contortion and faulting is also noticed high up on the western side of the gully formed by Beggs' Run.

About one and one-half miles south of Charlestown, on the western side of the railroad, is a quarry and a cement mill.

The base of the *black shale* is exposed at the top of the quarry.

Five feet of a *Crinoidal limestone* occur immediately beneath.

Below this are one and one-half feet of a rock, the lower eight inches of which are *conglomeritic*. The pebbles are small and black, usually one-fourth inch, rarely one inch, in diameter. One limestone pebble, two by four inches, derived from the cement rock, was found. At North Vernon this layer contains fish remains. It is there found, however, below the cement rock, instead of above.

Nine feet of *Cement rock* are worked in the quarry. The cement bed contains pebbles composed of material similar to the cement rock itself.

Below the cement rock occurs the *Corniferous*. The Corniferous is exposed along a stream southeast of the depot at Charlestown. The precise interval between the base of the cement rock at the quarry and the top of the Corniferous along the stream is not known, but is small.

5. Along a branch of Lick Run, southeast of the depot at Charlestown, the *Corniferous* is exposed. Its thickness is 18 feet. Fossils, especially corals, are abundant.

The underlying *Niagara* is an argillaceous limestone of light brown color. Fourteen feet below the Corniferous *Halysites catenulatus* is found; 18 feet below the Corniferous *Strombodes pentagonus* occurs; *Heliolites* and

Favosites are found just beneath; 22 feet below the Corniferous *Astylospongia praemorsa*, with well-preserved spicules, is seen; 70 feet below the Corniferous the well-known mineral or lick spring comes out just where a small stream enters Lick Run. The rock at the spring unquestionably belongs to the *Laurel bed* or *Cliff rock* horizon. The clay bed marking the horizon of the Waldron shale is found higher up, but its level was not recorded. Within 50 feet of the lick spring there is a waterfall, the rock at its top being at nearly the same level as the spring. The upper layer at the fall is composed of quite hard stone. The lower layers are softer and have been much contorted and otherwise disturbed, giving rise to a gentle folding of the overlying hard beds, especially in the layer which forms the top of the falls. A part, at least, of the lower, softer, contorted brownish argillaceous rock must belong to the horizon of the *Upper Osgood clay*. The thickness of this softer rock is 22 feet. Beneath it is found the *Osgood limestone*, usually strongly brecciated and much and irregularly contorted, the dip being in places vertical, although the folds are only of comparatively small dimensions. *Pisocrinus gemmiformis* and *Stephanocrinus osgoodensis* are found in the limestone.

The clay layer below the Osgood limestone was not found exposed. At one point, considerably down the stream, the *Clinton* was found in immediate juxtaposition with the Osgood limestone, but evidently faulted together. The Clinton, where best exposed, is 26 inches thick. It is of a salmon-brown color and contains the following fossils: *Illaenus madisonianus*, *Phacops trisulcatus*, a species of *Bellerophon*, *Plectambonites transversalis* var. *elegantula*, *Leptaena* (*Strophomena*) *rhomboidalis*, *Strophomena* (*Strophonella*) *patenta*, *Orthis calligramma* var. *eu-orthis*, *Orthis* (*Platystrophia*) *biforata*, *Orthis* (*Dalmanella*) *elegantula*, *Clathropora frondosa*, *Phaenopora fimbriata*, *Pachydictya bifurcata*, *Pachydictya turgida*, *Rhinopora verrucosa*, *Cyathophyllum celator* var. *daytonense*, *Streptelasma obliquius*.

6. The *Madison beds* have been contorted with the other rock. A thickness of nearly 40 feet of the characteristic brown argillaceous rock of this series is exposed beneath the Clinton at one point along the run. This is the most southern exposure of the Madison beds identified with certainty.

At the base of this section of the Madison beds is found a layer of argillaceous blue limestone, with *Orthis biforata*, *Orthis occidentalis* and Lower Silurian bryozoa. A short distance farther down Lick Run Lower Silurian fossils are very common. The Lower Silurian limestones at this point have a very decided dip, nearly 30 degrees at one place.

The contortion of strata has evidently affected all the beds from the lower part of the Laurel bed or Cliff rock to the fossiliferous Lower Silurian limestones.

7. The road from Charlestown to Bethlehem crosses Fourteen-Mile Creek just below the mouth of Collins Run. The *Corniferous* is exposed near the upper part of the road west of Fourteen-Mile Creek.

Ninety feet lower down the *Clinton* occurs. The rock immediately above the Clinton is considerably contorted, but the exposures are not good. The general color of the Clinton is light red, but at the falls on Collins Run the upper portion of the Clinton is of a salmon-brown color, and contains *Orthis calligramma* var. *eu-orthis*, *Orthis* (*Platystrophia*) *biforata*, *Favosites niagarensis*, *Halysites catenulatus*, and *Cyathophyllum calyculum*. Farther east the salmon-brown phase of the Clinton is absent. At the falls the Clinton is two and one-half feet thick.

A *very fine grained white limestone* is found immediately below. This is the layer found associated with the Clinton at Charlestown Landing. It is of Lower Silurian age. Below the limestone are found 16 feet of the brownish argillaceous Madison rock, an impure limestone. It is very characteristic in color and appearance. The Lower Silurian rock immediately below the Madison contains several layers of limestone, with branching bryozoans These layers are exposed beneath the Madison beds along Lick Run, and they are exposed without the Madison beds at several points along Lick Run and in the gully west of the Charlestown Landing road, as already stated. Their thickness is 13 feet. Beneath are five feet of blue clay and then five feet of very fossiliferous limestone strata as far as the lower bridge across Collins Run. These very fossiliferous strata occur also along Lick Run. Their position is from 18 to 23 feet below the base of the Madison beds, as is shown by the Collins Run section.

8. The *Madison beds* are also exposed along the roadside east of Fourteen-Mile Creek. The Clinton here is difficult to recognize. It is white, usually fine grained rock, in places coarsely crystalline, about 15 inches thick, changing below into a drab-gray rock. But one fossil was found in it, *Cyclonema bilix*, with the last whorl showing only transverse striae. The Clinton at Begg's Run is somewhat similar to the Clinton here, where it is fine grained and very hard.

Above the Clinton lie about two and one-half feet of clayey shale and clay, a six inch course of limestone, and then perhaps more clay, occupying the horizon of the Osgood clay beds.

9. The road from Charlestown to New Washington crosses a small branch near the southern margin of the A. J. Carr farm. The Niagara immediately below the Corniferous contains *Halysites catenulatus* and *Cladopora*.

10. The Corniferous is exposed along the same road, up the hill southwest of the mouth of Ninepenny Branch. The upper Niagara is about 38 feet thick, the clay marking the Waldron shale horizon is about eight

feet thick, and the exposures down to the base of the hill measure about 60 feet. The lower part of the Upper Silurian is not seen.

11. On the hillside north of the Tunnel Mill the Upper Niagara is at least 20 feet thick. At its base it contains a crinoidal layer with *Atrypa reticularis* and *Caryocrinus*. The blue clay marking the Waldron shale horizon is well exposed and is eight feet thick. The Cliff rock or Laurel bed series beneath the clay is at least 60 feet thick. It resembles the Cliff rock as exposed near Charlestown Landing. It is an impure limestone and is not like the white, fine-grained limestone which marks this horizon northward.

B BULL CREEK.

12. On the western branch of Bull Creek, where crossed by the road a little over a mile south of Hibernia (southeast end of the Plasket farm), the Clinton is exposed in the bed of the stream. The Clinton is 32 inches thick, siliceous, whitish where fresh, brownish where weathered, in some places crinoidal.

Above the Clinton are 10 feet of blue shale, representing the lower Osgood clay bed; five feet of limestone, representing the Osgood limestone; about two feet of blue shale, representing the upper Osgood clay bed, and at least 20 feet of limestone, representing the Cliff rock or Laurel bed.

Below the Clinton is a 12-inch layer of a dark, blackish, sandy rock, with fucoidal markings; 21 feet farther down are sun cracks and poor ripple marks on one of the layers belonging to the Madison beds. Thirty feet below the Clinton one of the Madison bed layers contains *Orthis occidentalis* and Lower Silurian gasteropods. *Orthis occidentalis* occurs again 43 feet below the Clinton. The Madison beds are about 46 feet thick. Beneath them Lower Silurian fossils are common in the clay and the abundant thin limestone layers.

13. On the eastern branch of Bull Creek, where crossed by the road a mile and three-quarters southeast of Hibernia, there is an old mill on the former E. Stricker farm. The Clinton forms a low fall north of the road. Its thickness is 32 inches; it is usually siliceous and fine-grained, but in a few places varies to white and crinoidal.

Above the Clinton are 11 feet of blue, shaly rock, representing the lower Osgood clay, and containing near the top an *Orthoceras* like *O. amycus*, but more rapidly tapering; five feet of limestone broken up, called rubble stone, representing the Osgood limestone; five feet of blue, shaly clay, representing the upper Osgood clay; at least 25 feet of limestone, representing the Cliff rock or Laurel bed. A blue, clayey shale occurs 70 feet above the Clinton, and probably represents the Waldron shale horizon.

Below the Clinton are found eight inches of a black, fine-grained, sandy rock with fucoidal markings. Immediately beneath are 80 inches of siliceous rock closely resembling the Clinton above but merging into the Madison beds below. The bluish Madison beds are often full of vertical worm borings.

C. CAMP CREEK.

14. A short distance below the juntion of the two main forks of Camp Creek the Bethlehem–Hibernia road crosses over an iron bridge. Near the hill top west of the bridge the Clinton is exposed. It varies from 12 to 21 inches in thickness, both the upper and the lower surfaces are irregular; it is siliceous, brownish, fine grained, varying in places to coarser grained limestone.

Bluish shaly clay occurs above the Clinton, but its thickness was not observed.

Below the Clinton are found 12 inches of a light brown or grey stone, with *Tetradium minor;* seven inches of similar stone; one-fourth to one inch of very thin limestone with *Murchisonia hammelli*; three inches of brown limestone; 16 inches of dark brown or black, fine grained, sandy rock; limestone with *Leperditia cæcigena*, and *Orthoceras* at the top.

Twenty-seven feet below the Clinton the Madison beds contain *Orthis biforata* and *Orthis occidentalis.* Down to 40 feet beneath the Clinton the Madison beds are more commonly blue in color. Their total thickness is 47 feet. Fucoidal markings are common.

Below the Madison beds are found 37 feet of rock in which these highly fossiliferous limestones are interbedded with a greater quantity of clay. Below that level the limestones form a more important element of the Cincinnati group.

15. About a mile and a half northwest of the last exposure an east and west road crosses the west fork of Camp Creek. On this road, at the southwest end of the A. L. Waters farm, the Clinton is exposed 150 feet above the bed of the creek. It is siliceous, light brownish, and 28 inches thick

Below the Clinton are eight inches of black, fine grained, sandy rock with fucoidal markings; 10 inches of softer, brown limestone; 10 inches of limestone which is blue when fresh; 18 inches of shale with *Labechia ohioensis*; 34 feet of Madison bed rocks; thin limestone beds with abundant Lower Silurian fossils are found 43 feet beneath the Clinton, and lower down; the gasteropod bed, corresponding to the Marble Hill quarry bed, occurs 133 feet below the Clinton, and 86 feet below the Madison beds.

16. About two and one-half miles north of the last exposure, where the Otto-New Washington road crosses the west fork of Camp Creek, is

an old mill, now known as Kelly's mill. Not far down the creek is a dam, and soon after the ruins of a second mill are seen west of the creek. Just below the dam the Clinton is found. It is 8 to 18 inches thick. It is siliceous, light reddish brown, and contains *Orthis calligramma* var. *eu-orthis* and *Cyathophyllum calyculum*.

Above the Clinton there are 13 feet of blue, clayey shale, the shaly partings being fewer and the rock harder near the top. This shale corresponds to the lower Osgood clay. Above the clayey shale are found several feet of limestone. Further up the stream towards the bridge a blackish, clayey shale layer occurs, which is about three feet thick. It contains limestone lenses with *Camarotæchia* and crinoid heads, and is believed to represent the upper Osgood clay bed. About 34 feet of the Cliff rock or Laurel bed occurs above the blackish, clayey shale. It contains frequent specimens of *Calymene niagarensis* and used to be worked for these fossils. About 20 feet of clay above the limestone, west of the creek, along the road, are believed to represent the Waldron shale horizon. Near the top it is sparingly fossiliferous and the following fossils were found: *Atrypa reticularis*, *Camarotæchia neglecta*, *Spirifer eudora*, *Duncanella borealis* and *Stephanocrinus hammelli*. Above the clay six feet of limestone are found, representing a part of the lower beds of the upper Niagara.

17. On the road from Bethlehem to Otto, near the top of the hill just west of Bethlehem, the top of the Madison beds are easily recognized. The Clinton seems to be a siliceous, light brown rock, not a foot in thickness, but no satisfactory exposures were found.

JEFFERSON COUNTY.

D. MARBLE HILL, SALUDA CREEK, AND NORTHWARDS.

18. From Marble Hill Postoffice a road leads down to the river landing. Turning off towards the right from this road, near the top of the hill, another road leads with very little change of level to some old quarries on the southern side of a deep ravine; a short distance beyond the road reaches the bluff above the Ohio River. The Clinton at the bluff measures 52 to 54 inches. It is siliceous, reddish brown, often coarse grained and difficult to distinguish from the Lower Silurian beds immediately below.

Above the Clinton are 12 to 15 inches of the basal Niagara limestone, of whitish color, then 12 feet of clay shale with *Orthoceras annulatum* and a cystidean near the top. This clay shale represents the lower Osgood clay. Above it lie five and one-quarter feet of limestone, formerly quarried for the manufacture of lime. This is believed to represent the Osgood limestone.

19. The road going due west from the north end of the cluster of houses at Marble Hill crosses a brook before reaching a school building. The limestone in the bed of this brook and for 10 feet up the hillside is believed to be the Cliff rock and the 10 feet of clay overlying the same is considered the representative of the Waldron shale, but the relation of these road exposures to the Marble Hill rocks was not carefully traced.

Below the Clinton, at the bluff above the Ohio River, lie seven feet of siliceous rock closely resembling the Clinton of this locality, but the color is more buff than reddish brown. Empty casts of crinoid stems are rarer, and it is softer. It is the top bed of the Lower Silurian. Rock of similar nature forms the top of the Lower Silurian two miles southeast of Hibernia at the southeast end of the Stricker farm, as already described, but at the latter locality the presence of the blackish rock with fucoidal markings makes the distinction between the Clinton and the Lower Silurian siliceous rock less difficult. Below the silicious rock are found three feet of thin brown shale, two and two-thirds feet of solid rock and about 48 feet of the Madison bed. The Madison bed is, however, so disintegrated below the bluff at the Ohio River front of the hill land that the lower part has the appearance of clayey shale or clay with occasional intercalated layers of limestone beds with few fossils. Abundant fossils make their appearance where the limestone layers become frequent, 60 feet below the Clinton.

20. The Madison beds are much better exposed along the road leading from Marble Hill down to the landing on the Ohio River. Bowlders from the gasteropod bed, once worked as a "marble quarry," occurred 80 feet below the Madison beds along this road. W. W. Borden, in his report on Jefferson county, estimates the thickness of the gasteropod bed at 20 feet.

21. About two miles north northwest of Marble Hill is the school house of District No. 2. The farm of Mart Payne lies at the end of a lane, directly north of the school. A small stream in the field northeast of the house runs northward to one of the many branches of Saluda Creek. The Clinton, as well as could be determined after a short search, was here siliceous, and about 16 inches thick. The precise separation of the Upper and Lower Silurian is difficult to determine.

Above the Clinton is a little rock; then one foot of blue clay; about two feet of stone; eight feet of blue clay; a total of about 12 feet of section, corresponding to the lower Osgood clay. Above this is limestone belonging to the horizon of the Osgood limestone. It contains *Pisocrinus gemmiformis* and *Pisocrinus benedicti*.

Below the Clinton the Madison beds occur in typical exposure, forming a steep grade, almost vertical in places, down which the stream rushes rapidly.

22. Going from school house No. 2 half a mile west, a quarter of a mile north, a quarter of a mile west, and then a mile north, the road crosses Saluda Creek just south of the house of Pinckney G. Swan. The Clinton can be recognized along the road side north of the creek crossing. It is light red, siliceous, weathering to an iron-stained brown. The upper 14 inches are without fossils, the lower 12 inches are more coarse grained and contain crinoid stems and *Cyathophyllum calyculum*, and some pebbles.

Above the Clinton are 10 to 12 inches of a whitish hard limestone; then 12 feet of blue clay, representing the lower Osgood clay. The Osgood limestone and the upper Osgood clay were not distinguished, though they may be present. The highest portion of the Cliff rock exposed is found 34 feet above the clay bed mentioned above.

Below the Clinton is found a decidedly clayey stone, and then the Madison bed. The Madison bed is probably 54 feet thick, the limestone beds becoming common at this distance below the Clinton. The gasteropod bed is found 60 feet below the Madison bed, and 50 feet farther down is the bed of Saluda Creek.

23. Going from the house of Pinckney G. Swan one mile northward and nearly a mile westward, the residence of D. P. Monroe is reached. A small stream flows directly south from his house towards Saluda Creek. A short distance before joining the creek it falls over a high fall, known as the Dog Falls. The Clinton is here 46 inches thick. The upper part of the Clinton is whitish with blotches of salmon-brown color. The main portion is salmon-brown. The lower four inches are in places white and fine-grained. The locality is not more fossiliferous than many others where the salmon-brown Clinton occurs, but more time was spent in collecting here, and, therefore, the list of species found in the Clinton is larger.

Illænus daytonensis, *Illænus ambiguus*, *Calymene niagarensis*, and *Dalmanites wertheni*. In the white limestone at the bottom of the Clinton were found *Lichas breviceps*, and an unknown Ostracod, *Bellerophon fiscello-striatus*, *Cyclonema* "*bilix*," the Clinton species, *Plectambonites transversalis* var. *elegantula*, *Leptæna* (*Strophomena*) *rhomboidalis*, *Strophomena hanoverensis*, *Strophomena patenta*, *Orthis calligramma* var. *dinorthis*, *Orthis* (*Platystrophia*) *biforata*. In the white part of the Clinton at the bottom were found *Atrypa marginalis*, *Clathropora frondosa*, *Phænopora expansa*, *Phænopora fimbriata*, *Phænopora ensiformis*, *Pachydictya bifurcata*, *Pachydictya turgida*, *Rhinopora verrucosa*, *Lioclemella ohioensis*, *Hemitrypa ulrichi*, *Heliolites subtubulatus*, and *Cyathophyllum calyculum*.

Above the Clinton are found 32 inches of the whitish basal Niagara limestone. Above this is a shaly rock, representing the lower Osgood clay. No attempt was made to distinguish the Osgood limestone or the upper Osgood clay. The base of the Cliff rock lies 20 feet above the basal Niagara limestone. Fourteen feet of Cliff rock or the Laurel bed are exposed near the falls.

Below the Clinton are found eight inches of rock with Ostracoda, *Entomis madisonensis*, *Leperditia cœcigena*, *Eurychilina striato-marginata*; two inches of limestone with *Orthoceras*, *Nucula* and other fossils corresponding to the *Murchisonia hammelli* layer on the Hitz's road near North Madison. Below are eight inches of hard, brown limestone, two inches of limestone with *Orthoceras*, *Nucula* and *Labechia ohioensis*. At the fall 30 feet of the Madison bed are exposed. *Orthis biforata* and *Orthis occidentalis* occur in hard, brown, impure limestones at several levels in the lower 10 feet of the series. The top of the Lower Silurian limestones, with abundant limestone layers, is found 60 feet below the Clinton. The junction of the Dog Falls stream with Saluda Creek is 20 feet lower down.

24. Half a mile west of Dog Falls is found the junction of the two main branches of Upper Saluda Creek. The rocks dip low eastward in this region. Both branches form falls over the Clinton rock within a short distance of their junction, and both have formed typical pot-holes in the Madison bed below. The northern branch has formed 21 of these, in rows across the stream, locating the former position of the falls. The Clinton is salmon-brown and 45 inches thick. About 12 feet of clayey limestone, with thin courses, overlie the Clinton, and correspond to the Lower Osgood clay. Limestone is found above.

Fifteen feet below the Clinton, wave marks occur in the Madison bed. Their trend is north and south. The lower half of the Madison bed contains impure limestone layers, with fossils at various levels. The junction of the Madison beds with the very fossiliferous limestone series at their base is well shown in the cliff opposite the mouth of the creek forming Dog Falls.

25. Following the road from D. P. Monroe's house a little over a mile eastward, the road turns southward and eastward again, reaching the house of Wallace Horrell, just beyond a small stream. From this point eastward, down the hill, the roadside exposes the section to be described. The Clinton is 10 to 12 inches thick; it is siliceous, slightly reddish, and could not be recognized if the accompanying overlying and underlying rocks were not exposed.

Above the Clinton are 10 inches of a clayey stone, and then 12 feet of blue clay shale and rubble stone, corresponding to the Lower Osgood bed and containing a *Strophomena*, related to *Str. patenta*, but with much coarser striations, *Pentamerus oblongus*, and a *Spirifer*, related to *Sp eudora*. Above the clay occur several layers of rock corresponding to the Osgood limestone. It is recorded in my notes as being siliceous, but seem to remember it as being crinoidal in some of its layers. Cherty beds occur above the white limestone, 50 feet above the Clinton. The white limestone belongs at the top of the Laurel limestone.

Below the Clinton are found four inches of light green, clayey rock, a dark brown layer eight inches thick, with very poor specimens of *Murchisonia*, a 12-inch layer of clayey stone with *Labechia ohioensis*, and then a thin layer with *Murchisonia hammelli*, *Holopea hubbardi*, and other fossils. The Madison bed is 65 feet thick. The gasteropod bed, corresponding to the Marble Hill quarry rock, occurs 80 feet below the Madison bed.

26. At the foot of the hill east of Wallace Horrell's farm, an old road leads northward, and within half a mile crosses a creek. From the creek to the top of the hill, at the residence of John Bair, there is quite a continuous exposure of rock. The Clinton is found near the top of the hill. It is reddish, weathers brownish, is irregularly bedded, and varies from 12 to 16 inches in thickness.

Above the Clinton are found eight inches of the white basal Niagara limestone, and 8 to 10 feet of blue clay, representing the Lower Osgood clay.

Below the Clinton is found a clayey, indurated stone, 22 inches thick; then four inches of clay with *Labechia ohioensis*, two inches of limestone, with *Murchisonia hammelli*, and an annulated *Orthoceras*. The Madison bed is about 45 feet thick. In the lower 10 feet are several layers of impure limestone with *Orthis occidentalis* and other fossils. The gasteropod bed, corresponding to the Marble Hill quarry rock, occurs 85 feet below the Madison bed.

E. HEARTS FALLS TO HANOVER AND CLIFTY FALLS.

27. From the Bair farm half a mile northward, half a mile westward, and then two-thirds of a mile northward, the road crosses a creek which a short distance farther down stream forms Hearts Falls. The Clinton is here 30 to 32 inches thick, and of salmon-brown color. Cherty beds occur in the Cliff rock, 43 feet above the Clinton. A clay bed occurs 47 feet above the Clinton and is believed to represent the Waldron shale.

28. Going from Hearts Falls a mile westward and nearly as far northward, a road leads eastward to the Chain Mill Falls, half a mile distant. The Clinton is here 50 to 52 inches thick, has a salmon-brown color, and is fossiliferous, but only *Orthis calligramma* var. *eu-orthis* and *Rhinopora verrucosa* are recorded.

Above the Clinton occur 22 inches of solid limestone, the basal Niagara; then six feet of shaly rock representing the Lower Osgood clay.

Immediately below the Clinton is rock with Ostracods. The layer with *Murchsonia hammelli* occurs 60 inches below the Clinton. The falls give a fine exposure of the Madison bed.

29. Two-thirds of a mile north of the Chain Mill Falls is Butler's Fall. The Clinton is exposed nine feet above the top of the falls. It is 27 to 29 inches thick, and is of salmon-brown color.

Above the Clinton are about 12 feet of a clayey rock, quite indurated, often broken up and rubbly, representing the Lower Osgood clay. Twenty-two feet higher up, on the road to Hanover, occurs the stone quarried for Science Hall of Hanover College. About seven feet of good quarry stone are found here, but the quarry has not been properly opened. Blue clay is found about 45 feet above the Clinton, west of the Hanover road. It is believed to represent the Waldron shale. The rock quarried for the Science Hall is therefore a member of the Cliff rock, or Laurel bed. Flinty layers occur near the top. Below the Clinton is found a layer with *Leperditia cæcigena*, 16 inches below the Clinton, *Labechia* occurs. The upper 20 feet of the Madison bed at the falls are composed of firmer, harder rock, and project beyond the lower, softer part.

30. Two-thirds of a mile north of Butler Falls, and directly south of the end of the Madison-Hanover Pike, are found the Crow Falls. The Clinton is here 16 inches thick, and contains *Orthis calligramma* var. *euorthis*, *Orthis* (*Platystrophia*) *biforata*, *Plectambonites transversalis*, var. *elegantula*, *Strophomena hanoverensis*, *Phaenopora ensiformis*, and *Rhinopora verrucosa*. Bluish rock with *Labechia* occurs four inches beneath the Clinton.

31. Soon after entering the grounds of Hanover College a path turns off towards the right and leads to a spring along the old, and now abandoned, Hanover Landing road. A water trough formerly stood at this point. The Clinton is here 36 inches thick. *Labechia* is found one foot below the Clinton. Along the new Hanover Landing road, a short distance away, the Clinton is only 17 inches thick.

Above the Clinton there is a considerable exposure of rock not carefully examined. The white limestone has been quarried near the junction of the Hanover Landing with the Hanover College road. The white limestone contains *Calymene niagarensis*, and near the top, 50 feet above the Clinton, it has cherty layers interbedded. The white limestone is believed to belong to the Cliff rock or Laurel bed horizon.

32. The base of the Corniferous occurs 40 feet higher up, in the bed of a small stream just west of the house of Prof. Culbertson.

33. Below the Clinton, on the Hanover Landing road, is the *Leperditia* layer, eight inches thick; then a fossil layer 17 inches thick with *Murchisonia hammelli*, *Orthoceras* and *Leperditia*. The Madison bed is 47 feet thick. *Favistella stellata* occurs near its base. The richly fossiliferous Lower Silurian limestones occur below the Madison beds, and thence down the hill.

34. Two-thirds of a mile northeast of Hanover College, on the road leading south from school house, District No. 6, the Clinton is 12 to 13

inches thick. Above the Clinton occurs a clayey, rubbly rock 15 feet thick, representing the Lower Osgood clay. The white limestone is exposed farther up the road, and a cherty bed occurs near the upper part, 45 feet above the Clinton.

Below the Clinton occurs the Madison bed. The fossiliferous Lower Silurian limestones become abundant 60 feet below the Clinton.

35. A mile northeast of the last locality, at the water-trough on the Madison-Hanover pike, the Clinton is 18 inches thick. It is salmon brown in color.

Above the Clinton is the solid, basal Niagara limestone, eight inches thick. Farther up is a clayey, rubbly material, nearly 10 feet thick, representing the Lower Osgood clay. A brown, impure limestone layer, 15 inches thick, seems to represent the Osgood limestone. The Cliff limestone is exposed 32 feet above the Clinton; 16 feet are visible, and the lower part is evidently not exposed.

A bluish, solid rock, with *Leperditia cæcigena* is found just beneath the Clinton.

36. A mile and a half west of Madison, the Madison–Hanover pike crosses Clifty Fork. Two miles up the stream occur the Clifty Falls. In the bed of the stream above the falls the Clinton is exposed. It is 11 inches thick. The upper portion is siliceous and light, reddish brown, and contains no fossils. The lower two to four inches are white and coarse-grained in some localities; it here contains a fairly abundant fauna—*Orthis calligramma* var. *eu-orthis*, *Plectambonites transversalis* var. *elegantula*, *Phænopora expansa*, *Pachydictya bifurcata*, *Pachydictya turgida*, *Pachydictya obesa*, *Rhinopora verrucosa*, *Heliolites subtubulatus*, *Cyathophyllum daytonense*.

Above the Clinton are found six to eight inches of the basal Niagara. The lower 28 inches of the clayey layer above are quite hard and indurated. Above this clay layer (not measured) there are four feet of limestone and three feet of clay, representing the Osgood limestone and the Upper Osgood clay. Twenty-four feet of Cliff limestone are exposed above the upper clay.

Below the Clinton is a bluish rock, with *Labechia*.

F. MADISON AND CROOKED CREEK.

37. Immediately west of the railroad track, at the west end of Madison, the Hitz Road, a private roadway, leaves the pike and ascends the hill toward the northwest. The locality was carefully examined in company with Mr. J. F. Hammell, of Madison, a well known geologist in these regions, and the collector of many new species of fossils in Jefferson County, described in the Indiana and other reports.

The Clinton varies from 15 to 22 inches in thickness. Its color is reddish, varying in places toward light brown. It contains a few pebbles, the largest measuring one and one-half, by one, by one-half inches. The fossils were few: *Orthis calligramma* var. *eu-orthis*, *Plectambonites transversalis* var. *elegantula*, *Pachydictya bifurcata*, *Heliolites subtululatus*, *Cyathophyllum calyculum*.

Above the Clinton are 10 feet of clayey rock, representing the Lower Osgood clay, 55 inches of limestone with several clay partings representing the Osgood limestone or Cystidean bed, and seven feet of material which is chiefly clayey and rubbly rock. The Osgood limestone, with that portion of the clay layers immediately above and below it, is the horizon of the famous Cystideans of Jefferson County. Nearly 10 feet of Cliff rock are exposed.

Immediately below the Clinton, *Byssonychia radiata* is found; below are 16 inches of light brown rock, with worm-borings; nine inches below is a nine-inch layer of bluish rock, with *Murchisonia hammelli*, *Holopea hubbardi*, and *Labechia;* just beneath *Orthis occidentalis* and branching bryozoa are found. The Madison bed is banded with light brown and purplish brown for 30 feet, then, farther down, 30 inches of shale, 11 inches of blue, clayey rock, and 54 inches of shale intervene before the first bed of *Favistella stellata* is reached, 40 feet beneath the Clinton.

38. East of the railroad the pike to North Madison presents a fine exposure of the Madison bed at the Hanging Rock. Farther up the road the Clinton is exposed. It is 22 inches thick. Its color is light red tinged with brown, but in places it is a little salmon-brown. The fossils are *Strophomena hanoverensis*, *Atrypa marginalis*, of the Brown's quarry type; *Rhinopora verrucosa*, and *Heliolites subtubulatus*.

Above the Clinton are eight inches of hard rock, like the siliceous Clinton, but more white in color; then eight inches of light brown rock, the basal Niagara; 11 feet of soft, clayey rock, corresponding to the Lower Osgood clay; above, it passes into a limestone which corresponds to the Osgood limestone. In the railroad cut a shale layer is seen above this limestone, and then the Cliff rock or Laurel bed comes in.

Below the Clinton, 16 inches, is a thin layer with *Murchisonia hammelli*, *Holopea hubbardi* and *Orthoceras*; 16 inches farther down *Orthis occidentalis* and numerous branching bryozoa occur. The Madison bed is well exposed. A short distance below its typical exposure the *Favistella stellata* bed occurs, and some distance lower the Cincinnati group limestones are common.

39. On the Michigan road the Clinton is 21 inches thick; it is siliceous and of a light, reddish brown. Above it is a drab transition rock 10 inches thick, similar to the layer described on the North Madison pike above the Hanging Rock. Above this lies an eight-inch layer of the undoubted basal Niagara.

Eight inches below the Clinton is a layer with *Murchisonia hammelli;* 16 inches below, the dark top of the Madison beds come in.

The following notes, published in the Indianapolis *Journal* for May 10, 1874, and kindly sent to me by Dr. W. T. S. Cornett, will be of service in comparison with other observations taken farther southward as well as near Madison. Immediately beneath the Clinton were found the following Lower Silurian fossils: *Orthis* (*Platystrophia*) *biforata*, var. *acutilirata*, *Orthis* (*Hebertella*) *occidentalis*, *Murchisonia milleri*, *M. bellicincta*, *Orthoceras junceum*, *Cyrtoceras sp.*, *Byssonychia radiata*. *Monticulipora frondosa*, *M. mammulata*, and *Batostomella* (*Chaetetes*) *gracilis*. In addition to this list, Mr. E. T. Cox published: *Orthis retrorsa*, *O. subquadrata*, *O. insculpta*, *Strophomena planumbona*, *Str. sulcata*, *Rhynchotrema capax*, *Rh. dentata*, *Zygospira headi*, and *Streptelasma corniculum*. These fossils occur in the layer immediately beneath the Clinton, and also in a thin layer lying 18 inches below the Clinton. Below this point lie 32 feet of nonfossiliferous rocks rapidly disintegrating or weathering, called in this report the Madison rocks. At their base some of the layers show sun cracks and ripple marks. Beneath the Madison rocks fossils are again common, the species being practically the same as those found above the Madison beds, mentioned in the preceding list. About seven and one-half feet below the Madison beds *Tetradium minor* occurs, the same fossil occurring again one and one-half feet farther down. Six feet below the last layer *Favistella stellata* is very common, and forms a well marked horizon 49 feet below the base of the Clinton. Two feet below the *Favistella* layer, or 302 feet above low watermark on the Ohio River a third layer of *Tetradium* occurs.

The thickness of the Clinton is not given in the Cornett section. According to my measurements it is 21 inches, in addition to which there are 10 inches of transition rock immediately above it. The combined thickness of the Clinton and the lower Niagara, up to the base of the more solid Cliff or Laurel beds of the Niagara, is 23 feet. The Cliff Niagara has a thickness of 13 feet; it is overlaid by 11 feet of a white limestone containing fossils, and this in turn by five feet of a bluish limestone containing *Pentamerus oblongus*. The upper rocks I did not see in my section along the Hitz road.

40. The Canaan road follows the valley of Crooked Creek. About two and a half miles north of Madison the Graham road branches off towards the northwest, and half a mile farther on it passes by a falls on the land of Mr. King. The Clinton is exposed near by, on the roadside. It is 18 to 23 inches thick, and of salmon brown color, except at the very top, where it is siliceous and of reddish brown color.

Above the Clinton lies the basal Niagara limestone, nine inches thick; then five feet or more of unexposed rock, five feet of impure limestone; and an unmeasured thickness of rock, resembling the Cliff rock. The upper part of the section needs further study.

Below the Clinton is one foot of bluish rock; then a clayey layer with *Labechia*; next, a blue rock again. Both blue rocks contain *Murchisonia hammelli; Byssonychia radiata* and an *Orthoceras.* The typical banded, reddish brown and greenish blue Madison bed is 35 feet thick. Below, the rock is similar in nature, but softer. It contains fossils at the base of the typical Madison rocks, and two feet farther down. A *Favistella* layer occurs eight feet, and another 12 feet below the base of the typical Madison rocks. The abundantly fossiliferous Cincinnati group limestone beds come in 65 feet below the Clinton.

41. The Canaan road, after passing the junction with the Graham road, ascends the hill toward the northeast. The Clinton is here 23 inches thick. The color is salmon-brown. The Cliff Niagara begins 30 feet higher up.

The typical Madison bed is about 30 feet thick. Shaly beds with limestone layers are found beneath it. They contain Lower Silurian fossils three feet below the typical Madison beds. The upper *Favistella* bed occurs 43 feet, and the lower 47 feet, below the Clinton, among layers of limestone full of Lower Silurian fossils.

42. The pike from Madison to Manville ascends the valley of the most southern branch of Crooked Brook. About one mile from Madison, at a bend in a road, there is a gully on the north side of the road. The Clinton at the top is six to seven inches thick. Its color varies at different places from siliceous and light brown to coarser grained and salmon-brown. It contains *Illaenus ambignus* and *Pachydictya turgida.* It is overlaid by four inches of a siliceous, very light brown rock. Above it are eight inches of grayish basal Niagara limestone.

Twenty-four inches below the Clinton is a dark blue bed with *Murchisonia hammelli* and *Orthoceras;* 33 inches below the Clinton a similar bed contains also *Labechia* and bryozoa. The Madison beds are 34 feet thick. *Orthis occidentalis* occurs near its base. A lithologically similar shaly material below the typical Madison beds contains frequent fucoidal markings.

G. LONESOME HOLLOW. EAGLE HOLLOW.

43. About half a mile in a direct line across the country south-southeast of the last locality, at the northern end of Lonesome Hollow, on the west side of John B. Cochran's farm, a roadway leading southward exposes the Clinton. It is eight inches thick and is overlaid by 20 inches of rock, which is a transition rock between it and the basal Niagara above. Overlying the latter are 14 feet of clay representing the Lower Osgood clay, three feet of limestone with *Pisocrinus gemmiformis*, representing the Osgood limestone, and then clay again—the Upper Osgood clay.

44. At the north end of Eagle Hollow, on the road south of the Ryker's Ridge Baptist Church, the Clinton is 28 inches thick. It is chiefly siliceous and reddish brown in color, and is overlaid by eight inches of basal Niagara. The Lower Osgood clay and the Osgood limestone, with *Pisocrinus*, occurs, but was not measured.

45. A mile southeast of the church is a tollgate. The Madison rock is well exposed a quarter of a mile west of the same.

H. PLEASANT RIDGE AND RIKER'S RIDGE.

46. A road follows the main valley of Bee Camp Creek. Within a hundred feet of its junction with the Pleasant Ridge pike there is a fine exposure. The Clinton is here 13 inches thick. It is siliceous and light reddish brown.

Above the Clinton lie six inches of whitish basal Niagara limestone.

The Madison beds are banded with brown and gray green, and are about 40 feet thick. Below the Madison bed is a clayey shale with dark fucoidal markings, 18 feet thick. At various levels it contains thin limestone layers; one of these, three feet above the base, contains *Strophomena sinuata*.

47. A little over half a mile eastward, in a gully east of the Pleasant Ridge Church, the Clinton is eight inches thick. It is siliceous and of a light reddish brown color. Above it are fifteen feet of clayey shale, then three to four feet of limestone and blue clay again, representing the Lower Osgood clay, the Osgood limestone and the Upper Osgood clay.

48. Half a mile south of the church, on the Pleasant Ridge road, the Clinton is fourteen inches thick. It is silicious, and of a light reddish brown color. Above it are six to eight inches of basal Niagara limestone, of light drab color.

49. At the western end of Wolf Run, near the head waters of the stream, northeast of the Ryker's Ridge Baptist Church, an exposure is found on the northern side of the stream. The Clinton is 34 inches thick; it is light brownish and contains numerous angular fragments and lenses of a whitish rock.

Above the Clinton are eight inches of basal Niagara limestone, 14 feet of clayey rock, the Osgood clay; four feet of limestone, the Osgood limestone, and an upper clay layer, the Upper Osgood clay.

A short distance below the Clinton is *Leperditia cæcigena*. The Madison bed is exposed farther down.

50. The Ryker's Ridge road goes from the Baptist church half a mile northward, and then eastward to the house of James H. Carr. In a small run north of the house the Clinton is exposed. It is reddish brown, 24 inches thick, and near the top contains fragments and lenses of a grayish rock.

Above the Clinton lie 16 feet of clay, the Lower Osgood clay, five feet of a hard limestone, much weathered, the Osgood or Cystidean limestone, and then four feet more of clay with numerous fossils, the Upper Osgood clay. The upper clay contains *Platystoma niagarensis*, *Leptaena rhomboidalis*, *Atrypa reticularis*, *Anastrophia internascens*, *Camarotœchia indianensis*, *Rhynchotreta cuneata* var. *americana*, *Whitfieldella nitida*, *Spirifer eudora* and *Spirifer crispus*.

51. Northwest of Carr's house, on the west side of the ridge road, behind an orchard, the same section is exposed.

I. WESTERN BRANCH OF INDIAN-KENTUCK.

52. At the head of Schnapps Creek, or Comb's Run, east of the Canaan road, along a road following the valley, the Clinton is 20 inches thick. It contains angular masses and lenses of a whitish rock. The fossils are *Orthis calligramma* var. *eu-orthis*, *Orthis* (*Platystrophia*) *biforata*, *Strophomena hanoverensis*, *Strophomena patenta*, and *Rhinopora verrucosa*.

Above the Clinton are 10 inches of basal Niagara; 14⅓ feet of clay, four feet of limestone and five feet of clay, the Osgood series, covered with more limestone.

53. A road traverses the length of the ridge north of the Schnapps Creek valley. A mile east of the Canaan road church the Clinton is 24 inches thick.

54. Half a mile north of the church just mentioned, on the Canaan road, the Clinton is 25 inches thick, and contains lenses of white stone. The fossils are *Plectambonites transversalis* var. *elegantula*, and *Orthis elegantula* var. *parva*.

Below the Clinton is a blue clayey limestone. About five feet below the Clinton *Ostracoda* are common; six feet below the Clinton, ripple marks occur. Though distinct, the ridges are only two inches apart and run N. 50 E.

55. The various larger forks of Razor Creek all form considerable falls over the Madison bed. The most northerly branch of the creek forms a fall a short distance east of the Graham road, southeast of the house of Mr. Geisler. The Clinton at this point is 23 to 25 inches thick and has a salmon-brown color.

A short distance above the Clinton there is a clay bed. The base of the Cliff Niagara is about 25 feet above the Clinton.

Below the Clinton are 25 inches of a siliceous fine-grained rock, whitish or tinged with brown; 12 inches of clay rock with *Labechia*; a bluish rock with *Murchisonia hammelli*, *Byssonychia radiata* and *Orthoceras*. A similar rock occurs three feet lower down. Three feet lower, the top of the falls is found. The upper part of the Madison bed is composed of whitish rock, similar to the Belle-view exposure.

56. Going a mile south of Mud Lick or Belle-view and then a mile eastward, the farm house of Stephen Aich is reached. South of the road the Clinton is exposed in the bed of the brook. It is light red and four inches thick, becoming eight inches thick northeastward in the road bed.

Above the Clinton are three inches of basal Niagara limestone, 13½ feet of the lower Osgood clay, 38 inches of Osgood or Cystidean limestone, four feet of the upper Osgood clay and the lower part of the Cliff rock.

Below the Clinton are 14 inches of dark blue rock with *Leperditia caecigena*, five inches of similar rock, six inches of bluish rock with *Murchisonia hammelli*, *Holopea hubbardi* and *Orthoceras*; 50 inches farther down *Labechia* occurs in a clayey bed.

57. Nearly a mile north of Belle-view, just before reaching a road corner with a grist mill, a stream passes beneath an arched stone culvert. A short distance eastward it joins another stream, and a short distance farther the united stream falls over a small exposure of the Clinton. The Clinton is 33 inches thick. It is chiefly of salmon-brown color, but some light brown and a few very dark brown layers were found. It contains the following fossils: *Proetus determinatus*, head and pygidium, *Illaenus daytonensis*, *Illaenus ambiguus*, *Illaenus madisonianus*, head and pygidium, *Calymene niagarensis*, *Lichas breviceps*, *Pterinea brisa*?, *Bellerophon fiscello-striatus*, *Platystoma niagarense*, *Plectambonites transversalis* var. *elegantula*, *Orthis calligramma* var. *eu-orthis*, *Orthis* (*Platystrophia*) *biforata*, variety with three median dorsal plications, *Orthis* (*Dalmanella*) *elegantula*, *Leptaena* (*Strophomena*) *rhomboidalis*, *Strophomena hanoverensis*, *Strophomena* (*Strophonella*) *patenta*, *Strophomena tenuis*, Clinton precursor, *Ptilodictya whitfieldi*, *Clathropora frondosa*, *Phaenopora fimbriata*, *Rhinopora verrucosa*, *Aspidopora parmula*, *Favosites niagarensis*.

Above the Clinton is the basal Niagara; then about eight feet of clay rock, turning near the top into a sort of rubble stone, representing the Lower Osgood bed. The Osgood limestone and the layer of blue clay above the same are also represented here, but not in very typical form. A considerable exposure of Cliff rock occurs along the upper part of the creek.

Below the Clinton are 12 inches of greenish blue, clayey rock, soft above, harder below, without fossils, 10 inches of blue limestone, fine-grained, with abundant *Leperditia cæcigena*; eight inches of bluish limestone with deep brown, sandy courses, or lenses, of very irregular outline. Beneath this the upper 20 feet of the Madison beds occur, but their appearance is unusual, the rock being usually a white limestone, instead of an argillaceous banded rock. The blue phase with *Murchisonia hammelli*, *Holopea hubbardi* and *Orthoceras* occurs 10 feet below the Clinton, and layers with *Leperditia* occur at quite a number of levels. The typical banded Madison rock is found at the lower falls quite a distance down the stream, where 15 feet of typical Madison rock are exposed. The richly fossiliferous Cincinnati limestones are found farther down along the branch into which the stream just followed empties.

58. In the northeast corner of Monroe Township, a mile and a half north of Bryantsburg, a road leads from the Michigan pike a mile eastward to the western fork of Indian-kentuck Creek. A quarter of a mile farther east it crosses a branch of the creek. Just above the bridge the Clinton is exposed in the branch. It is 12 inches thick, of a light brown color, and contains *Halysites catenulatus.* The locality was visited in company with Mr. J. F. Hammell, who succeeded in recognizing his Çystidean beds in the section.

Above the Clinton are the basal Niagara, six inches thick, and three feet of rock and clayey shale similar to the basal Niagara. Above it are eight feet of clayey shale without fossils, the Lower Osgood clay, and eight inches of a soft, clayey shale. Mr. J. F. Hammell informs me that this upper clay is the lowest level at which he has found his Niagara Cystideans. Twenty-four inches of indurated clay rock contain, according to Mr. Hammell, most of the Cystideans. At our visit two Cystideans were found *in situ.* Thirty-eight inches of limestone, with intercalated clay partings occur here. The limestone contains various brachiopods, and is the Osgood limestone. Cystideans are often found on the upper or lower surface of the limestone layers, partly exposed, but can not be freed from the rock. Occasionally Cystideans are found free in the clay partings between the limestone Twenty-four inches of clay next follow and forms the highest level at which Cystideans were found by Mr. J. F. Hammell, although none were found by us. Six feet of clay shale, the Upper Osgood clay, succeed, followed by the Cliff rock or Laurel lime stone.

The locality here described is not a rich Cystidean locality, but stratigraphically, the beds which along Big Creek carry the Cystideans were also present here, and the information of Mr. Hammell made it possible to locate the position of the Cystidean beds in the Osgood series very accurately.

59. A quarter of a mile south of Canaan a road turns westward, and within a mile and a half reaches an exposure of the Clinton, where the road descends one of the upper branches of the Dry Fork Valley. The Clinton is 21 inches thick, has a salmon-brown color, and contains masses of a whitish rock. The fossils are *Illaenus daytonensis*, *Plectambonites transversalis* var. *elegantula*, *Leptaena* (*Strophomena*) *rhomboidalis*, '*Strophomena* (*Orthothetis*) *tenuis*, Clinton precursor, *Strophomena patenta*, *Camarotœchia scobina*, *Clathropora frondosa*, and *Rhinopora verrucosa.*

Above the Clinton the Lower Osgood clay, the Osgood limestone, the upper Osgood clay and the Cliff rock may be recognized. The flinty rock near the top of the Cliff rock is found 50 feet above the Clinton.

Wave marks occur in Dry Fork 85 feet below the Clinton. The ridges run N. 70 W., and are about 20 inches apart.

60. The Clinton is exposed on the Madison-Canaan road, half a mile northeast of its crossing over the west fork of Indian-kentuck Creek. *Favistella stellata* is very common at its proper horizon farther down the hill.

J. HALL'S RIDGE TO CANAAN AND THE COUNTY LINE.

61. A considerable thickness of Clinton, as nearly as I can remember about 30 inches (not recorded), was exposed about a mile south of Canaan, where the road descends into a deep valley and turns eastward. It is again exposed where the road ascends the opposite side of the valley and continues as the Hall's Ridge road.

62. At the most southern outcrop on Hall's Ridge the Clinton is 32 inches thick, and has a salmon-brown color.

63. On the eastward extension of Hall's Ridge, on the land of Ab. Rogers, the Clinton is poorly exposed in the roadway. The thickness is at least 12 inches.

64. On the White-eye Hill road, a mile southeast of Canaan, the Clinton is 12 to 15 inches thick, has a reddish-brown color, and contains fragments of a whitish rock. Above it are six inches of basal Niagara limestone, 14 feet of the lower Osgood clay, 50 inches of the Osgood limestone, and the upper Osgood clay.

65. The Clinton is exposed at several points on the road east of Canaan. Directly north of Canaan, at the edge of town, it is exposed in a ravine. The Clinton is here 36 inches thick, and varies from light reddish brown to salmon brown in color. The various Osgood beds are also well exposed.

66 Going from Canaan, a third of a mile westward and two miles northward, a stream is crossed just before reaching a school house and church. West of the road the Clinton is exposed in the bed of the stream. It is thirty-three inches thick and has a salmon brown color.

67. A mile further north, just north of the Jefferson County line, a stream crosses the road, and a short distance east of the same it exposes the Clinton. The Clinton is 47 inches thick, and has a salmon brown color. Lenses of a whitish rock are not uncommon at various levels. The fossils are *Illaenus daytonensis*, *Illaenus ambiguus*, *Orthis calligramma* var. *euorthis*, *Strophomena hanoverensis*, *Strophomena patenta*, *Clathropora frondosa*, *Phaenopora fimbriata*, and *Rhinopora verrucosa*.

Above the Clinton are six inches of the basal Niagara limestone; 11½ feet of the Lower Osgood clay; 30 inches of the Osgood limestone, with *Pisocrinus gemmiformis*; four feet of the Upper Osgood clay, and a considerable thickness of the Cliff rock or Laurel bed.

K. BARBERSVILLE AND NORTHEASTERN CORNER OF COUNTY.

68—69. The Clinton is well exposed southwest of Barbersville, and at various points along the road from Barbersville to Hicks' Postoffice, where the road takes a southwesterly course before reaching Hicks' Postoffice.

70. Precisely four miles east of Canaan, in a direct line, is a school house on an east and west road. A short distance eastward a light red limestone about eight inches thick, presumably a portion of the Clinton limestone, is exposed in the roadbed. Farther eastward the Lower Silurian is exposed, with *Leperditia caecigena*, *Murchisonia hammelli*, *Orthoceras*, and a lamellibranch.

71. Towards the southeast, in the bed of a dry run, a light, reddish-brown rock was seen, which may occupy the Clinton horizon, but it was impossible to identify its horizon with certainty. About a third of a mile westward a few salmon-brown Clinton bowlders were seen.

72. Two miles directly northward, on Poplar Ridge, there is another school house at a road angle. A third of a mile eastward the road turns northward, and west of the road, while digging a well, about 30 inches of a reddish-brown rock were struck, similar to the dry run exposure just mentioned. This may also represent the Clinton horizon.

L. PARIS CROSSING.

Paris Crossing.—Nine miles southwest of Dupont, on the railroad leading from North Vernon to Louisville, is Paris Crossing. The Devonian crinoidal limestone is exposed half a mile south of the village, on the western side of the railroad; about five feet are exposed. The cement rock, a blue, fine-grained stone, of value commercially near Charlestown and southward, is about three feet thick. The Corniferous is exposed down to the level of the railroad track, five feet, but its total thickness is about seven feet or a little more. The Upper Niagara, a dolomitic limestone, is about 25 feet thick. It is exposed along the banks of Graham Creek, east of the railroad. A short distance southward the railroad crosses a road by means of a trestle. This point is called the Under-cut. Opposite the Under-cut, the lower banks of Graham Creek expose about five feet of Waldron shale, full of fossils. These fossils have been collected chiefly by collectors living in Hanover, Indiana; the collectors have obtained at this point a large part of the fossils first cited from Waldron, Indiana.

See, in this connection, a description of the section at the Tunnel Mill, south of Vernon, in Jennings County.

M. BIG CREEK, FROM DUPONT EASTWARD.

73. A short distance south of Dupont the railroad crosses Big Creek. Half a mile up the stream the clay of the Waldron shale horizon is quite fossiliferous, and contains the following species:

Duncanella borealis, *Streptelasma radicans*, *Cyathophyllum calyculum*, *Striatopora gorbyi*, *Favosites spinigerus*, *Callopora elegantula*, *Fenestella* sp., *Lecanocrinus pusillus*, *Eucalyptocrinus crassus*, *Orthis* (*Rhipidomella*) *hybrida*, *Orthis* (*Dalmanella*) *elegantula*, *Orthotetes subplana*, *Plectambonites* sp., *Leptaena rhomboidalis*, *Spirifer crispus*, *Spirifer niagarensis*, *Whitfieldella nitida*, *Camarotœchia neglecta*, *C. acinus*, *C. whitii*, *Anastrophia internascens*, *Atrypa reticularis*, *Platyostoma niagarense*, *Cornulites proprius*.

Farther up the creek, about two miles east of Dupont, is the Reuben Walker bridge. The Cliff rock here is at least 36 feet thick, and has been worked for bridge foundations. It is a first-class quality of rock, comparable with the Laurel limestone in the more northeastern counties. The Waldron clay overhanging the Cliff rock is 14 feet thick east of the bridge. Farther up stream, the base of the Cliff rock is found nearly eight feet below the Osgood limestone. On ascending the stream, all three formations are frequently exposed.

74. The localities which have furnished most of the cystideans collected by Mr. J. F. Hammell begin about three miles west of Bryantsburg and extend up Big Creek for two or three miles. Along this stretch the cystidean beds are frequently exposed.

75. About two miles west of Bryantsburg, on the north side of the stream, the following very typical section was found. Mr. Hammell supplied the data as to the cystidean beds.

Several feet of clayey shale, overlaid by two feet of more indurated clay rock, being the upper part of the lower Osgood clay. Greenish clay shale, a few inches, with few but very fine cystideans; hard, greenish clay shale, eight inches thick, the main cystidean bed; eight inches of greenish clay shale, rarely with cystideans. Twenty-one inches of irregular limestone layers, with *Holocystites wykoffi*, *H. spangleri*. Twelve inches of clay shale, with limestone nodules, containing *Stephanocrinus*, *Eucalyptocrinus* and *Caryocrinus hammelli*; in places it is full of fossils, and in others it is barren. Eighteen inches of a very hard crinoidal limestone, with *Holocystites ornatus* on its surface next succeeds, and above this is clay. A limestone layer, one and one-half inches thick, is sometimes found seven inches above the hard limestone; it contains *Holocystites ornatus*. The cystideans continue to be found in the clay beds for about 20 inches above the thin limestone; *Holocystites gyrinus* is found here. The space between this and the base of the Cliff rock is about five feet. It is the Upper Osgood clay horizon, but contains thin limestone layers at various horizons.

The cystidean beds include, therefore, the upper part of the Lower Osgood clay, the Osgood limestone and the lower part of the Upper Osgood clay.

76. This is the most northern point along Big Creek, according to Mr. J. F. Hammell, where the cystidean beds are exposed. If so, they recur again in the bed of Big Creek farther northward in Jefferson County.

RIPLEY COUNTY.

N. BIG CREEK AND WEST FORK OF INDIAN-KENTUCK.

77. In Ripley County, a mile and a half north of the county line, Big Creek is crossed by an iron bridge, on the road to New Marion. The Osgood limestone here contains *Dalmanites limulurus*, *Plectambonites transversalis*, *Leptaena* (*Strophomena*) *rhomboidalis*, *Orthis flobellites*, *Orthis elegantula*, *Orthis*, related to *O. daytonensis*, *Atrypa reticularis*, *Spirifer radiatus*, *Caryocrinus ornatus* and *Pisocrinus gemmiformis*.

78. Half a mile northward, on the land of Orvin Campbell, the same limestone contains also *Calymene nasuta*.

79. A mile north of the county line, the west fork of Indian-kentuck is crossed by a road. The Osgood limestone contains *Pisocrinus gemmiformis*. The Lower Osgood clay is well exposed down stream. The Upper Osgood clay, with the lower part of the Cliff rock, are seen on ascending the hill.

O. EAST FORK OF INDIAN-KENTUCK.

80. Directly east of Haney's Corner the Clinton is 48 inches thick. Its color is salmon brown. The Osgood series is also exposed. The Clinton is again seen half a mile eastward, just before reaching a church.

81. A mile north of Haney's Corner a branch of Indian-kentuck exposes the Clinton. It is 48 inches thick, is of a salmon-brown color and shows no pebbles. It contains many fossils.

Above the Clinton are 10 inches of a siliceous, reddish-brown rock—the basal Niagara. The Lower Osgood shaly clay is 11 feet thick. Near its top a cystidean was found. The Osgood limestone is represented by 25 inches of limestone, eight inches of clay and 10 inches of limestone. The Upper Osgood clay is 10 feet thick. The Cliff rock is exposed at the cross-roads northward.

82. About a mile northeast of Barbersville the Clinton is 36 inches thick and of salmon-brown color.

83. A mile farther north the salmon-brown Clinton is 30 inches thick.

84. Half a mile farther north and one and one-half miles directly

mica and has a salmon-brown color. A few white pebbles occur.

54. Half a mile farther north and one and one-half miles directly

east of Haney's Corner is the farm house of Mr. Means. The Clinton is exposed in the run in the field northwest of the house. It is salmon brown in color, is 21 inches thick and contains *Illaenus ambiguus*, *Proetus determinatus*, *Orthis elegantula*, *Plectambonites transversalis* var. *sericea*, *Leptaena* (*Strophomena*) *rhomboidalis*, *Strophomena hanoverensis*, *Strophomena tenuis*, Clinton precursor, *Phaenopora fimbriata*, *Rhinopora verrucosa*, *Aspidopora parmula*.

Four feet below the Clinton *Tetradium minor* is found, accompanied by *Orthis biforata* and *Streptelasma corniculum*. Immediately below is a dark brown rock with fucoidal markings, similar to the layer in the Saluda Creek exposures. Three feet lower is the bluish layer with *Murchisonia hammelli* and *Orthoceras*.

85. A mile north of Haney's Corner, and then a little over a mile eastward, the road crosses a stream. Here the Clinton seems to be siliceous and of a reddish brown color. It is five to six inches thick. Some distance above is limestone with *Pisocrinus gemmiformis*, the Osgood limestone.

86. A mile northeastward, where the east and west road crosses the creek, and is joined by the creek road, there is an exposure. It is a little over a mile west southwest of the southern end of Benham's Corner. The Clinton is here 54 inches thick. Its color is salmon brown. No pebbles were seen.

Above the Clinton are nine inches of the siliceous reddish brown rock, identified as Clinton in some of the more eastern and southeastern sections. Above this are 16½ feet of the Lower Osgood clay shale, 12 inches of limestone with *Pisocrinus gemmiformis*, *Caryocrinus ornatus*, a *Whitfieldella* related to *W. cylindrica*, *Orthis elegantula*, *Atrypa reticularis*, and *Duncanella borealis*. Above are four to six inches of clay and 12 inches of limestone, the two limestones representing the Osgood limestone. The fossils occur in the limestone and the clay immediately above.

Below the Clinton are Lower Silurian fossils. *Tetradium* is common five feet below the Clinton.

87. A mile south of the cemetery, near the southern end of Benham's Corner, along a creek road, the Clinton is 25 inches thick, and of a salmon brown color. It continues to be exposed for half a mile up the creek, and is richly fossiliferous. Only *Illænus daytonensis* and *Triplesia ortoni* were recorded. Pebbles are very rare. Five feet below the Clinton, *Tetradium* is common.

Northward, where the road leaves the creek, the Osgood beds are exposed. Just south of Benham's Corner the Cliff rock occurs.

88. A mile down the creek, following the road, a road turns off directly southward. In a direct line the locality is about three-fourths of a mile southwest from the last. The Clinton is here at least 16 inches thick and has a salmon-brown color. A few white pebbles occur.

89. About a mile east of the last locality, just before reaching a school house, the Clinton is exposed along the roadside. The exposure may be reached by going from Cross Plains one mile northward and a little over a mile westward. The Clinton here varies from six to nine inches in thickness. The upper portion at one point is crinoidal, and has a salmon-brown color. The middle and lower portion, and usually all of this thin layer of Clinton, is conglomeritic. Some of the white pebbles are three inches long, but most of the pebbles are small, about the size of fine gravel. Even in this conglomeritic portion there are, here and there, crinoidal remains of salmon-brown color. The lower part of the conglomeritic layer at times has a black color, and then is unlike anything ever seen in the western Clinton. In various parts of the Clinton conglomerate layer the much rolled fragments of Lower Silurian fossils may be distinguished. *Orthis occidentalis* is the most common species. In the clay beneath the Clinton Lower Silurian fossils are abundant.

P. TRIBUTARIES OF WILSON'S FORK. CROSS PLAINS.

90. Two miles west of Cross Plains, at a spring in the roadside, the Clinton is 13 inches thick, and has a salmon-brown color. It contains small white pebbles, similar to those at Osgood, but smaller, varying from one-quarter to one-half inch in size. It contains *Illaenus daytonensis* and *Orthoceras ignotum.*

91. At the north end of Cross Plains Village a siliceous, light reddish brown rock is seen. Its thickness is about nine inches. It is overlaid by whitish rock, followed by shale—the Lower Osgood shale.

92. A mile north from Cross Plains, and then a mile west on the crossroad, an exposure is found in the bed of a stream. The Clinton is a silicious, reddish brown rock. The Lower Osgood clay shale occurs above. The Cincinnati group occurs below.

93. Half a mile northward, on the east and west road, occurs another exposure. From the cemetery at Benham's Corner the road leads east one sixth of a mile, south three-quarters of a mile, after one eastward turn in the road, south one-quarter of a mile, then east three-quarters of a mile. The Clinton is exposed in a little stream bed north of the road. It is siliceous, reddish brown in color, and nine inches thick. The blue Cincinnati rocks occur below.

Q. OLEAN TO VERSAILLES.

94. Going from the cemetery at Benham's Corner one mile north, and then a short distance east, the road crosses a small stream. North of the road the stream gives a fine exposure of the salmon-brown Clinton, 36 inches thick. Lenses of white rock occur in the Clinton, but no real pebbles were noticeable

95. Half a mile northwest of Olean, on the road leaving the north end of the village, the salmon-brown Clinton is 24 inches thick.

The Clinton is again exposed before reaching the northern line of Brown Township.

96. Northwest of Olean the Clinton is exposed at several points where streams cross the road. A little over half a mile northward there is a stream which exposes the Clinton at a small fall west of the road. It has a salmon-brown color, is 50 inches thick, and is full of fossils. East of the road there are two falls in the Madison beds. The lowest and highest of these is known as Cooper's Falls. The upper strata are here 29 feet below the base of the Clinton, and 28 feet above the base of the falls, giving a total section of 57 feet to the Madison beds. These Madison beds, however, resemble the sections given by the falls near Laurel more than those at Madison, in that there is a considerable quantity of clayey shale in the section.

97. Three-fourths of a mile northward the Clinton is exposed at the top of Curran's Falls, east of the road and a short distance north of the junction of two roads. The Clinton is of a salmon-brown color, is 46 inches thick, and near the bottom contains plenty of white pebbles, similar to those found at Osgood. The pebbles are usually one-fourth of an inch in length, but some two inches long are found. The pebbles sometimes show the presence of worm burrows, filled with the salmon-brown Clinton material. These pebbles may have been formed from a Lower Silurian stratum, such as is frequently found immediately beneath the Clinton.

98. A mile and three-quarters northwards, the Clinton east of the road is 64 inches thick. It contains lenses of white rock.

99. The first Clinton outcrop along the road, going south from Versailles, occurs one-third of a mile north of the locality just mentioned. Clinton bowlders, derived from the field, are found, however, at various points farther northward.

100. In the southwestern part of Versailles, on the road to Tanglewood, west of a saw-mill, so many Clinton bowlders have been picked up in the fields that the line of Clinton outcrop can be well followed. The Clinton here contains many white pebbles.

R. VERSAILLES TO OSGOOD.

101. *Versailles*—about five miles south of Osgood. About two miles south of Osgood the old road to Versailles leaves the pike and takes a straighter but more hilly course for Versailles. About a mile farther on, Cedar Creek comes within 50 feet of the road. Poor wave marks occur in one layer of limestone in the bed of the creek, the ridges running N. 80 W. The rock along both sides of the bank is Lower Silurian. The highest exposures on the hillside and along the small branch entering

Cedar Creek from the west, are still Lower Silurian, although some of these Lower Silurian limestones are very white and lithologically resemble some of the Niagara limestones found elsewhere. Lower Silurian fossils, however, overlie these white limestones and exclude the idea of the presence of Niagara rocks in this vicinity.

101 *a*. About two miles southward, the old road to Versailles passes down a steep incline into the deep valley of a branch entering Cedar Creek from the west. About opposite to the beginning of this steep descent of the road the bed of Cedar Creek, over a hundred feet down, shows limestone beds with well defined wave marks, the ridges running N. 18 W., the crests being 23 to 25 inches apart and from one to one and one-third inches above the deepest part of the depression between the ridges. Lower Silurian fossils are very common at this low level, *Tentaculites* (species unknown), *Orthis* (*Dalmanella*) *testudinaria* and *Strophomena filitexta* being common. Lower Silurian fossils occur up to the very summit of the hills bordering the valley.

Ascending the hill on the side of the valley formed by the branch of Cedar Creek already mentioned, the rather steep road enters Versailles from the north. A very detailed section of the upper portion of the exposures along this road was prepared and will serve to show some of the main lithological features of the upper Lower Silurian at this point. The section is given in descending order, going from the north end of Main Street, in Versailles, northwards down the road.

In the clay overlying the limestones, at the very top of the section, are found *Orthis* (*Platystrophia*) *biforata*, *Orthis* (*Herbertella*) *occidentalis*, *Strophomena sulcata* and *Callopora* (*Monticulipora*) *ramosa*, showing that no Upper Silurian rocks occur at this point. Beneath the clay occur: five inches of limestone, siliceous, with concretionary bodies of small size, and containing at one place a specimen of *Byssonychia* (*Ambonychia*) *radiata*; 10 inches of limestone, with fossil shells replaced in part by crystalline calcite; 11 inches of solid bluish limestone, apparently with *Isochilina*; 15 inches of irregularly seamed limestone, bluish and brownish, with an interior cast of *Byssonychia* (*Ambonychia*) *radiata*; 19 inches of more solid blue limestone; 41 inches of a bluish, more clayey rock, weathering along minute cracks to a brownish color, giving the rock a sort of reddish effect at a distance. This rock at times has a purplish-brown hue, and apparently contains *Isochilina subnodosa*; beneath it are eight inches of solid blue limestone; 15 inches of fragments of rock with *Isochilina subnodosa*; 15 inches of solid blue limestone with *Tetradium minor* on the upper surface. Towards the east, along the creek side, this layer shows fine vertical borings, possibly made by annelids; beneath this layer, on the creek side, are eight inches of clay; four inches of limestone; four inches of limestone; six inches of limestone; 10 inches not exposed; 48 inches of a rubbly-brown, clayey rock, like the much cracked *Isochilina* layer mentioned above; five feet not exposed. Then, along the roadside again, 11 inches of a more solid rock layer, full of fossils, especially along the upper surface, such as *Byssonychia* (*Ambonychia*) *radiata*, and the thicker species of *bryozoa*; seven inches of solid blue limestone, with *bryozoa* well shown along the upper surface; six inches not exposed; nine inches of solid blue limestone, with numerous vertical holes; four inches of thin limestone layers; 16 inches of very solid blue limestone. Next come 106 inches of brownish and bluish, thin, practically unfossiliferous shales, with good shaly partings; 10 inches of solid blue limestone; eight inches of shale; seven inches of blue limestone; five inches of shale. Next come 17 inches of limestone with *Byssonychia* (*Ambonychia*) *radiata* and *Tetradium minor*; beneath it, separated by a clayey parting, come 16 inches of blue limestone with *Orthis* (*Platystrophia*) *biforata* and *Tetradium minor*; 45 inches of a rubbly-blue limestone, with frequent specimens of *Tetradium*; 33 inches of similar stone with *Tetradium*; 15 inches of solid rock, composed almost altogether of *Tetradium*. Then occur 16 inches of bluish clay with *Favistella stellata*, followed by 12 inches more of clay; four inches of limestone, with frequent specimens of *Orthis* (*Platystrophia*) *biforata*, and *Orthis* (*Herbertella*) *sinuata*, of very characteristic form, and quite common; 76 inches of shaly rock, containing several thin limestone courses; eight inches of limestone in two layers, with numerous fossils, among these *Strophomena* (*Rafinesquina*) *alternata*; 18 inches of clayey rock; four inches of solid limestone; 15 inches of thinner limestone courses; eight inches of limestone; five inches of limestone. Then, going down the hill, there are about 30 feet of rocks not well exposed along the road. Beneath this occur 40 feet of very fossiliferous strata, containing an abundance of all sorts of fossils, down to the level of the creek. Among these fossils are: *Orthis* (*Herbertella*) *sinuata*, *Strophomena filitexta*, *Strophomena* (*Rafinesquina*) *alternata*, *Leptæna* (*Strophomena*) *tenuistriata*, *Rhynchotrema* (*Rhynchonella*) *capax*, *Pterinea demissa*, and *Streptelasma corniculum*.

In condensed form the section may be said to consist of five feet of limestone, five and a half feet of the *Isochilina* bearing clayey rock, a *Tetradium* layer, one foot thick; two and two-thirds feet of limestone rock; four feet of the clayey rock, similar to that containing *Isochilina* higher up; nine feet of limestone layers, a total so far of 27 feet, chiefly of limestone. Beneath this are found nine feet of unfossiliferous brownish and bluish shales, two and a half feet of limestone and shale, 12½ feet of layers containing *Tetradium*, with a layer containing *Favistella* beneath, a total distance of 52 feet beneath the top of the section. Next beneath are 10 feet of chiefly clayey material, often with shaly partings, three feet of limestone, thirty feet of unknown character and about 40 feet of very fossiliferous limestones and clayey shales to the bed of the creek, a total of 125 feet to the section.

A third way of describing the section would be, a thickness of 85 feet of rock and shale but moderately supplied with fossils, underlaid by 40 feet of fossiliferous limestones and shales.

In this form the section can be used to determine the relative position in the Lower Silurian of various exposures along Laughery Creek and its branches in Ripley County. The Clinton is exposed on the southwestern side of Versailles. The Niagara is not present in the immediate vicinity of Versailles, although found farther westward. It is not probable that the Niagara occurs anywhere towards the east of Versailles, the line of outcrop passing from Osgood toward the west of Versailles.

102. About half a mile east of Osgood, on an east and west road, at least four inches of Clinton rock are exposed. It is of salmon-brown color and contains many white pebbles. Some of the pebbles are three inches long. Beneath the Clinton is a four-inch layer of white limestone with Lower Silurian fossils, which has furnished the material for the pebbles.

103. About a mile and a half south of Osgood, at the end of a short branch of the railroad, is Nick Wagner's quarry. The Laurel formation is here well exposed, and the following thicknesses of limestone are secured, the ledges being followed from the bottom upward: 6, 16, 8, 3, 10, 7, 4, 5½, 3, 5, 5, 7, 5, 5 inches. From the eastern side of the quarry a creek flows eastward. This exposes, several hundred yards away, a ledge of limestone on a level with the base of the quarry, with *Pisocrinus gemmiformis*. Shaly rock seems to underlie it.

104. A mile southwest of Osgood, on the northern side of the railroad track, is Al. Ashman's quarry.

Beginning with the bottom, the Laurel limestone presents the following layers: 16, 9, 3½, 8, 9, 5, 11, 11, 8, 6, 10, 14, 8, 11 and 4 inches.

105. In the northeastern part of Osgood, along the road south of the railroad track, the Clinton is 28 inches thick. It has a salmon-brown color and at its base includes pebbles of a whitish Lower Silurian limestone. The fossils are *Illaenus daytonensis*, *Illaenus ambiguus*, *Plectambonites transversalis* var. *elegantula*, *Orthis calligramma*, *Rhinopora verrucosa*, *Heliolites subtubulatus*.

Above the Clinton is the Lower Osgood clay horizon, about 76 inches thick. Then come in several limestone beds with *Atrypa reticularis*.

106. At the north end of Osgood are some quarries exposing the Osgood limestone, about 30 inches thick. The Clinton is found eastward in the bed of a stream in a field, eight feet below the Osgood limestone. The partings between the Osgood limestone layers contain many fossils.

S. OSGOOD TO NAPOLEON AND VICINITY.

107. From Osgood two miles northward on the Napoleon pike, and thence eastward one mile, there is an exposure of the Clinton in the bed of a stream north of the road. The Clinton is here quarried for road material. It is of salmon-brown color, is 34 inches thick, and at its very base contains pebbles and brecciated fragments of white rock. Lenses of white rock occur at various levels in the Clinton.

The layer of Cincinnati limestone just beneath the Clinton is very white and fine-grained, and probably furnished a part of the pebble material at the base of the Clinton.

The fossils in the Clinton are: *Illænus daytonensis*, *Illænus madisonianus*, *Plectambonites transversalis* var. *elegantula*, *Leptæna* (*Strophomena*) *rhomboidalis*, *Strophomena hanoverensis*, *Strophomena patenta*, *Strephomena tenuis*, *Orthis calligramena* var. *euorthis*, *Orthis* (*Platystrophia*) *biforata*, *Orthis* (*Dalmanella*) *elegantula*, *Clathropora frondosa*, *Phænopora fimbriata*, *Pachydictya bifurcata*, *Pachydictya turgida*, *Rhinopora verrucosa*, *Heliolites subtubulatus*, *Favosites favosus*, large tubes, *Halysites catenulatus*, *Cyathophyllum caliculum*.

108. The Clinton is exposed a quarter of a mile farther east, on the roadside east of a cemetery. Twenty-six inches are here seen, but the exposure is not a good one.

109. A mile eastward, and then a mile northward, the northern end of a long hill is reached. Going down into the valley northward, solid layers of Lower Silurian limestone are found 53 feet below the summit of the hill land. The limestone is two and one half feet thick, and is underlaid by eight and one-half feet of shaly stone similar to that found in the section immediately north of Versailles. At Versailles the shale layer is about nine feet thick and is found about 28 feet below the top of the exposed section. The Clinton occurs at Versailles not far above the top of the section as exposed north of town. Judging from this the level of the Clinton should occur considerably below the hill top at section 109, here described. The Lower Silurian limestone farther down the hill, and also half a mile westward, where a stream crosses the east-west road, contains concretions enclosing fossil remains.

110. A mile and a half northwest of the last locality, on the road to Napoleon, the salmon brown Clinton is 14 inches thick. It contains *Orthoceras virgulatum* (?) and *Phænopora fimbriata*. The Lower Silurian limestone immediately beneath is white in color, and is penetrated from above by worm burrows which are filled by salmon-brown Clinton material. The burrows were evidently made in Clinton times. A short distance westward, southeast of a road corner, the Laurel limestone, or Cliff rock, is quarried by Jos. Remstedt.

111. From this road corner, half a mile westward and then half a mile northward, the Osgood limestone with *Pisocrinus gemmiformis* is exposed on the east side of the road at a creek crossing. A little over half a mile northward the Clinton is exposed just south of a road corner. The Clinton is exposed several times a quarter of a mile farther north. Beneath the Clinton at this locality there is a four-inch layer of white Lower Silurian limestone, with over three feet of clayey material, full of loose fossils. The locality number refers to this exposure.

112. A third of a mile northward is an excellent exposure of the Clinton on the east side of the road in a stream bed. Its thickness is five feet. Its color is salmon brown. It contains lenses and, in places, even layers of white rock. This rock, in places, contains worm burrows filled with the salmon brown material from the layers immediately above. The fossils are *Strophomena hanoverensis*, *Orthis calligramma* var. *dinorthis*, *Clathropora frondosa*, *Rhinopora verrucosa*, *Heliolites subtubulatus* and *Favosites niagarensis.*

113. The Clinton is exposed along a stream bed a third of a mile northward, north of the crossroads, and also a quarter of a mile and again half a mile east of this road corner.

114. At Napoleon the stream bed exposes the white Laurel limestone. North of the town, a fifth of a mile east of the Napoleon-Greensburg road, the Osgood limestone is exposed in the stream bed. Along the same stream, nearly three-quarters of a mile north of Napoleon, the salmon-brown Clinton is exposed on the west bank. It is 14 inches thick and overlies a hard, whitish or grayish, shaly parted limestone. A fifth of a mile northward the east bank of the stream exposes Lower Silurian rock, richly fossiliferous.

115. A quarter of a mile southward, on the west side of the stream, north of the roadbed there is an exposure of salmon-brown Clinton two feet thick. It is not exposed in the roadbed, nor on its southern side. The place of the Clinton seems to be occupied by a hard, whitish, shaly parted limestone. The exact relation of this rock to the Clinton is not known, the intermediate region being not sufficiently exposed. But it is not impossible that the Clinton turns within a few feet to a fine-grained, whitish limestone. Above the Clinton lie three or four inches of clayey white limestone, then 12–15 inches of Madison-like, brownish limestone. The Osgood limestone occurs several feet higher up, westward, in the roadside. Below the Clinton are thin courses of brownish and bluish shaly and clayey limestone, without fossils, excepting worm burrows.

116. A third of a mile westward, and then a quarter of a mile northward, just north of a road corner, a small branch crosses the road at the house of David L. Eaton. The base of the Cliff or Laurel limestone is exposed along the road, and also above the stream east of the road. Only

two and one-half feet are exposed. Beneath this are three inches of shale, six inches of clayey limestone, nine inches of shale, four inches of limestone, and then a little over four feet of shale. This shale does not seem to occur in the sections near Osgood. It replaces in part the base of the Laurel bed. Below this shale is found the top layer of the Osgood limestone. It is 11 inches thick, and contains *Pisocrinus gemmiformis*, *Illaenus insignis*, and other fossils. Beneath this layer are found two feet of softer, irregular bedded limestone, which weather back, and evidently correspond to the rubbly limestone of the sections near Osgood. Beneath this, but west of the road, down the stream, are found 12–15 inches of the Madison-like, brownish, clayey rock. Below this are two to three inches of the whitish basal Niagara limestone with crinoid beads. The Clinton, immediately beneath, thickens within a short distance, on going eastward down the stream, from 15 to fully 30 inches. Its color is salmon brown. The top of the Lower Silurian is formed by a white limestone layer.

T. MOST NORTHERN EXPOSURES ON LAUGHERY CREEK AND ITS DECATUR COUNTY BRANCHES.

117. The Rolfing and Wagner school house locality was visited on a former occasion. The Clinton is about one foot thick, and has a salmon-brown color. Above the Clinton were two feet of whitish limestone, apparently the Osgood limestone. The shaly layers immediately above correspond to the shaly layers as seen at the last described locality. See in this connection the New Point section, where this shale does not occur, and where the section can be better compared with the Osgood section.

118. A mile eastward, the Clinton is exposed along the road side, south of the bridge leading across Laughery Creek. It is salmon brown in color. Its total thickness is unknown.

119. The Clinton is exposed again nearly two miles northward, nearly half a mile south of New Pennington, in a small stream bed. The Lower Silurian is crossed by the road bed.

120. A mile east of New Pennington a stream exposes, along its banks, the fossiliferous Lower Silurian.

121. A road leads southward on the western side of the stream. A mile and a half southward along this road the salmon-brown Clinton is exposed west of the road, along the high banks of the stream. It occurs again at various points farther southward. None of these exposures have any considerable thickness, but the total thickness of the Clinton is probably not exposed.

U. NEW POINT.

New Point Quarry.—A mile north of New Point, east of the road, along a branch of Salt Creek, at the east end of the Big Four quarries, a quarter of a mile west of Rossville. Along the creek the salmon-brown Clinton is 33 inches thick. It contains *Clathropora frondosa* and numerous other fossils. Below the Clinton is a white layer of Lower Silurian limestone, underlaid by softer blue limestones and clayey shales.

Over the Clinton lie 44 inches of a clayey limestone; above this lie 18 inches of rubble limestone with clayey partings; the limestone is fossiliferous, and weathers back. Above this are two feet of rubble limestone, weathering less easily, and containing numerous fossils. Above this lies a 12-inch layer of solid limestone, the Osgood limestone. Immediately above begins the Cliff bed or Laurel limestone. This part of the section corresponds closely to the section at 104, at the quarry a little over a mile southwest of Osgood, and also to the lower part of the section at 116, David L. Eaton's, two miles south of Napoleon. The railroad company quarries the inferior clayey rock just above the Clinton, under the name of a soap-stone, the lower layer being eight inches thick, the upper 26 inches. The inferior rubble limestone comes out in ascending order in 15, 12–15, 24 and 12–24-inch layers, according to the quarrymen. This rock consists essentially of irregular limestone patches in a soft, clayey rock which will not withstand weathering. Over this is an 18–20 inch layer of a clayey rock which will not withstand weathering, which is called the soap stone ledge. Over this, according to the quarrymen, lie the following layers of white limestone: 8, 36, 18, 9, 12, 9, 14, 10, 8, 7, 6, 4, 3 inches These upper layers are composed of an excellent quality of white limestone. The lower eight-inch layer may possibly represent the Osgood limestone of the creek section. The upper layers are the Clift or Laurel limestone. The lower, Osgood, beds should not be used for purposes where weathering may endanger the rock. The softness of the same layers 200 feet away, along the creek, shows their inferior character when exposed to weathering. Sometimes the upper two to four inches of Clinton are so firmly united to the base of the Niagara, as to be quarried up with the latter.

V. BIG GRAHAM CREEK AND LITTLE OTTER CREEK.

122. The most eastern exposure of the Clinton along Big Graham occurs a little over a mile south of Versailles, on the road to Titusville. Its thickness could not be determined; its color was salmon brown.

123. The next exposure is a mile and a half southwest of Versailles, on the road to Tanglewood church, where a small stream crosses the road.

It is near the Adam Caplinger house. The Clinton is 28 inches thick, has a salmon-brown color, and contains, near the base, pebbles of white rock.

Above the Clinton are six to eight feet of greenish-brown shales, the equivalent of the Osgood clay.

The Clinton contains the following fossils: *Illænus ambiguus*, *Proetus determinatus*, *Plectambonites transversalis* var. *elegantula*, *Leptæna* (*Strophomena*) *rhomboidalis*, *Strophomena hanoverensis*, *Strophomena tenuis*, Clinton precursor, *Orthis calligramma* var. *euorthis*, *Orthis elegantula* var. *parva*, *Atrypa latacorrugata*, *Clathropora frondosa*, *Heliolites subtubulatus*.

About four or five feet beneath the Clinton base, fragments of Lower Silurian rocks were dug out of the bottom of the stream bed, and contained in the bluer layers: *Orthis* (*Platystrophia*) *biforata*, *Orthis* (*Herbertella*) *occidentalis* and *Protarea vetusta*. In the white limestones, associated with the bluer layers, are frequent specimens of *Tetradium*, frequently penetrated by the limestone cement along vertical cavities, probably caused by boring animals.

124. Three-quarters of a mile westward and half a mile southward is Tanglewood church. A stream crossing the road shows the Clinton, quite a distance east of the road. The Clinton is of salmon-brown color and contains white pebbles.

Above the Clinton are eight feet of clayey shale, the Lower Osgood clay. Then 32 inches of limestone in several courses, some of them separated by thin clay layers. The lower layer of limestone contains a *Whitfieldella* related to *Wh. cylindrica*. Above the Osgood limestone, west of the road, there is no exposure for about four feet; this, with the lower portion of the next higher exposures, gives a total thickness of about six to eight feet to the Upper Osgood clay. Above this lie 10 feet of white limestone, the Laurel bed. The upper layer of this limestone is coarse grained and contains *Dalmanites limulurus*. *Pisocrinus gemmiformis*, *Atrypa reticularis* and *Spirifer crispus* are found at various levels. The Laurel bed is worked under the name of Ead's quarry.

The Laurel bed is also exposed northward at John Jackson's quarry, a quarter of a mile west of the Adam Caplinger exposure.

125. Nearly two miles southward, where the creek road crosses over to the north side of the creek, going west, a small stream enters from the south. The Clinton in this stream is only four inches thick, and is full of white pebbles. The Lower Silurian beneath the Clinton is a mass of whitish rock fragments and clay, at least five feet thick.

126. A mile westward, on a road leading northward from the creek road, the salmon-brown Clinton is 15 inches thick, and includes white pebbles near its base. It contains *Orthis calligramma* var. *euorthis*, *Phænopora fimbriata*, *Heliolites subtubulatus*, *Halysites catenulatus*.

Above the Clinton are at least six feet of soft, clayey shale, and then white limestone with a *Whitfieldella* related to *Wh. cylindrica.*

Immediately below the Clinton is white Lower Silurian limestone, with a species of *Lophospira* and *Orthis biforata.* In the creek bed are thick massive clayey limestones, with *Leperditia* and other remains, similar to the upper beds of Lower Silurian age, north of Versailles.

127. A little over half a mile westward, south of the Big Graham, where the road crosses to the southern side, at least 10 inches of salmon-brown Clinton, containing pebbles, are exposed.

128. A fourth of a mile westward, a partly abandoned road leaves the creek road and ascends the valley of a branch, northward. About a mile and a half north of the Big Graham this branch is joined by another stream. Along the road, near the junction, the Clinton boulders are often eight inches thick and contain pebbles. The color is salmon brown.

129. Half a mile southwest of the junction of the northern branch with the Big Graham, a small stream crosses the road east of William Muth's house, just before reaching the point where the creek road crosses over to the north side of the creek. The Clinton in the stream bed is four inches thick, has a salmon-brown color, and contains white pebbles.

The Lower Osgood clay shale and the Osgood limestone are well exposed.

The section along the creek road does not show any Clinton.

130. Nearly a mile southwest of this locality is the Michigan Road. Along the creek road, a hundred feet northeast of its junction with the Michigan Road, the Clinton is absent.

The base of the Niagara is represented by a four-inch layer of bluish-white limestone. The clayey shale and rubble stone above this represent the Osgood clay, and are about eight feet thick. Three layers of limestone with the interbedded clayey shale, measure three feet in thickness, and represent the Osgood limestone. Fossils are found in this stone, and in the clay immediately above.

Below the basal Niagara is a four-inch layer with *Labechia.* Below this layer Lower Silurian fossils are common.

In the Osgood beds, in the limestone layers and the associated clays, are found *Orthis calligramma* var. *euorthis, Whitfieldella,* a form related to *Wh. cylindrica, Atrypa reticularis and Spirifer radiatus.* Loose slabs of Osgood limestone contained in addition: *Dalmanites limulurus, Orthis (Dalmanella) elegantula, Plectambonites transversalis, Rhynchotreta cuneata* var. *americana, Pisocrinus gemmiformis, Stephanocrinus osgoodensis,* and *Caryocrinus sp.*

131. On the southern side of the Big Graham, a short distance south of the last exposure, and at the northern end of New Marion, the Clinton is also absent. The basal Niagara is eight inches thick. It is overlaid by 10½ feet of Lower Osgood clay, 34 inches of the Osgood lime-

stone, in several courses with clay partings, and six feet of the Upper Osgood clay. The lower part of the Cliff rock is seen farther up the road; at least 10 feet are exposed.

Below the basal Niagara are 20 inches of blue shaly clay, and then nine feet of clay with numerous Lower Silurian fossils. There are five feet of solid limestone, beneath which there are three feet of clayey limestone like the layers containing *Leperditia*, north of Versailles.

The Osgood limestone and the immediately overlying clays contain many Niagara fossils. Those from the clay can be easily secured. In addition to the fossils found north of the creek, there are here seen: *Leptœna rhomboidalis* and *Spirifer eudora.*

The Laurel limestone contains *Pisocrinus benedicti.*

132. The Clinton is also absent along the Big Graham, where crossed by the New Marion-Butlerville road, one-half mile west of New Marion. The basal Niagara limestone is 11 inches thick. The Lower Osgood clay is at least eight feet thick. The Osgood limestone and the Upper Osgood clay were not measured. The Cliff rock is at least 15 feet thick.

Below the basal Niagara are six inches of clay with *Streptelasma corniculum*, *Orthis occidentalis*, and *Callopora* (*Chaetetes*) *dalei.* The highest limestone layer of Lower Silurian age contains *Labechia.*

133. A mile and a third west of New Marion the Butlerville road is crossed by a small stream. West of its junction with the Big Graham the Clinton is exposed on the hillside. It is seven inches thick, has a salmon-brown color and contains plenty of white pebbles in the lower half.

Immediately beneath the Clinton is a white Lower Silurian limestone similar lithologically to that composing the pebbles.

134. A mile and a half southwestward, where Haines' branch crosses the east and west road, south of the Big Graham, the upper 18 inches of the Clinton do not contain pebbles. The lower four inches of the Clinton contain numerous, chiefly small, pebbles. The total thickness is 22 inches; the color is salmon brown.

The basal Niagara is siliceous and is nine inches thick. The upper layer of limestone of Lower Silurian age is of drab color and is four inches thick. Beneath are six feet of Lower Silurian rock.

135. A mile west of the Haines' branch exposure, where the road reaches the creek and soon after becomes indistinct, the salmon-brown Clinton is 10 inches thick. The lower six inches contain pebbles, some of them two inches long.

The basal Niagara is three inches thick. The Lower Osgood clay is nine feet thick. The Osgood cystidean limestone is 42 inches thick and contains *Illaenus ioxus* and other fossils.

136. No Clinton is exposed 200 feet west of the last locality. It is certainly absent in the stream bed, one-fourth of a mile southwestward.

137. Half a mile westward, west of the cemetery northeast of Benville, the stream exposures show one inch of Clinton of salmon-brown color, consisting chiefly of small pebbles, but also containing *Orthis calligramma* var. *euorthis* and *Strophomena patenta*. The basal Niagara is two and one-half inches thick. The bluish rock at the top of the Lower Silurian is four inches thick. It was cracked before the deposition of the Clinton material began, and salmon-brown Clinton material now fills up the cracks. At some points along the stream no Clinton can be found.

138. The northeastern exposure of the Lower Silurian along Little Otter Creek is two and one half miles northwest of New Marion, in a direct line, and two and one-fourth miles east of the county line. No Clinton is present. The white siliceous limestone, usually found above the Clinton in the western part of Ripley County is here two inches thick. The 15 inches of thin layers of white limestone beneath the two inch layer resemble thin Niagara flagging stones, but are believed to be of Lower Silurian age. Beneath this is a dark shale with fucoidal markings, resembling the dark shale with the fucoidal markings in the Saluda Creek exposures.

139. A mile southwestward, south of a school house, the road exposure does not show any Clinton, but a little westward, along the roadside, the Clinton was at least six inches thick and contained white pebbles. Its color is salmon brown.

140. A mile westward, where the creek is crossed by a road, one-fourth mile east of the county line, there is no Clinton. The basal Niagara limestone is white and siliceous, like that near Benville. The upper portion of the Silurian is bluish and contains many specimens of *Byssonychia radiata* and other more common fossils. The Osgood limestone contains *Pisocrinus gemmiformis*. The Lower Osgood clayey shale is well exposed on the northern side of the creek, west of the road crossing.

W. BIG OTTER CREEK AND BRUSH CREEK.

141. The Al. Ashman quarry, locality 104, is found a little over a mile southwest of Osgood, north of the railroad. There is an almost continuous exposure of the Laurel formation for nearly three-fourths of a mile westward to where the salmon-brown Clinton is exposed in the creek bed east of an old abandoned road, northeast of a farmhouse. The Clinton is at least six inches thick. The thin basal Niagara is not exposed. The clayey bed immediately above is 44 inches thick. This layer often resembles the Madison bed, which is, however, Lower Silurian. Above the clayey rock are 40 inches of clayey and rubbly limestone, followed by three inches of clay, and then by 11 inches of solid Osgood limestone. The Cliff or Laurel limestone can not be sharply distinguished from the

Osgood limestone, the Osgood bed forming the base of the almost continuous limestone section. I examined the clay layers immediately above and below the Osgood limestone for cystideans, but did not find any.

142. A mile west-northwest, east of a branch of the creek, along the road-side, the salmon brown Clinton is at least six inches thick. It contains a few small white pebbles. Beneath the Clinton lie eight inches of white Lower Silurian limestone; then Lower Silurian rock full of bryozoans. Above the Clinton, ten feet eight inches, is a 14-inch layer of Osgood limestone, with *Pisocrinus gemmiformis*. Below this thick bed are several thinner limestone layers, also with crinoidal remains.

143. A short distance westward and then three-fourths of a mile northward, the salmon-brown Clinton is exposed where a small stream crosses the road. It is 15 inches thick, and contains a few white limestone pebbles three inches long. Six inches below the Clinton is a 12-inch layer of crystalline, white, glassy limestone, containing long cavities, in some cases evidently locating the former presence of branching bryozoans, their structure being still retained around the margins of the cavities.

144. The Lower Silurian limestone, nearly two miles down the creek, south of a road crossing, contains concretions around small fossil remains.

144a. From locality 142, a short distance westward, and then half a mile north on the Michigan Road, to a stream; the salmon-brown Clinton is at least eight inches thick; total thickness not known. It is cross-bedded. Below it is Lower Silurian limestone, eight inches thick, containing large oölitic concretions.

144b. A short distance northeast, at another road crossing, the banks of the stream expose Osgood limestone.

144c. Half a mile northward, on the east side of the stream, the bank exposes 15 inches of Osgood limestone, over three inches of clay, and three feet of rubbly limestone.

145. A mile and a quarter north of Osgood, and then a mile and a half westward, the road crosses a stream emptying into the northern branch of Big Otter Creek. South of the road the upper layer of Osgood limestone is 14 inches thick; it is underlaid by three inches of clay, and then by 19 inches of limestone in thin courses, the whole representing the Osgood limestone. Below are found 20 inches of thin rubble limestone with clay partings. Then 39 inches of Madison-like, light brown, clayey rock, fairly solid, but becoming soft under the influences of weathering.

146. Farther down the stream, west of the Michigan road, the salmon-brown Clinton is exposed. A considerable distance west of the road the Clinton is well exposed, and is 24–27 inches thick. It contains *Clathropora frondosa* and *Heliolites subtubulatus*.. The Clinton rests upon

white Lower Silurian limestone. This is penetrated by worm burrows filled with salmon-brown Clinton material. Farther down stream the Lower Silurian limestone below the Clinton is four to eight inches thick, contains numerous concretions, and also bryozoans and gasteropods. The upper surface of the Lower Silurian is a little uneven, the base of the Clinton being let down into the depressions of the Lower Silurian.

147. A mile directly westward, where the two main forks of the northern branch of Big Otter Creek meet, there are three feet of salmon-brown Clinton limestone exposed.

148. Half a mile southward the Clinton is better exposed. It is salmon brown in color and 50 inches thick. Above it are 40 inches of the Madison like clayey rock, 40 inches of rubble limestone and a 15 inch layer of Osgood limestone, with a thin clay layer between this and the rubble limestone beneath.

Below the Clinton are two inches of white Lower Silurian limestone, three feet of clayey material with bryozoans and fragments of thin limestone, a 12 inch layer of limestone with bryozoans, eight inches of clay, three feet of more solid limestone with *Tetradium*, then three feet of fossiliferous limestones alternating with clay, finally four feet of solid limestone full of fossils and containing numerous limestone concretions.

149. Half a mile down the creek, west of the road where it crosses over to the western side of the creek, the salmon brown Clinton is 15 to 18 inches thick. It contains very few pebbles. Ten and one-half feet above the Clinton the Osgood limestone is 12 inches thick; the rubbly limestone occurs below.

150. Half a mile southward the steep banks east of the creek, 15 feet above the creek, show an 18 inch bed of Lower Silurian limestone full of *Tetradium;* three feet higher up, loose blocks of *Labechia* are found.

151. Half a mile southward, northwest of a school house, at the road corners west of the creek, the top of Lower Silurian section contains concretions in the limestone layers. Above this are specimens of *Labechia* and then 25 feet above the creek is found the salmon-brown Clinton. Only eight to 12 inches are exposed, and this is evidently not the total thickness. It contains lenses and even thin intercalated layers of whitish limestone. A hundred feet north of the school house the Clinton contains white, fine grained limestone pebbles of Lower Silurian origin.

152. About two miles down the creek, along the road going west from the creek, the Clinton is absent, but a pebble of Clinton rock, three inches long, nearly as broad, and one-half inch thick, was found within two inches of the base of the white basal Niagara limestone. Its color was salmon brown, mixed with blackish. Immediately beneath was clay with *Tetradium*, then Lower Silurian fossils, and farther down was Lower Silurian limestone with small concretions. The base of the Niagara was 40 feet above the creek.

153. East of the creek, along the same road, the Niagara is underlaid by clay and then the *Tetradium* layer. The Clinton is absent. Some distance down is Lower Silurian limestone with concretions, and still farther down is limestone with ostracod remains, among others a species with a vertical groove, near the middle of each valve, extending a short distance downward from the hinge.

154. A mile southwestward down the creek, northward along the road leading up from the creek, worm burrows of a very peculiar character are found in the Lower Silurian. They resemble, crudely, specimens of *Orthoceras*, with partitions, but without a siphuncle.

155. South of the road, along the western bank of the creek, the Lower Silurian limestone contains concretions. A little higher up is found the basal Niagara limestone, overlying a thin blue clay layer, with branching bryozoans of Lower Silurian age.

156. Three-fourths of a mile southwestward down the creek, on the western side of the creek, large *Tetradium* masses are found. They belong to the variety which seems to be massive below, but which occasionally branches above. Immediately above is the white basal Niagara limestone, 15 inches thick, formed of thin courses. The Clinton is absent. Below the *Tetradium* layer is Lower Silurian limestone with large oölitic concretions, fragments of *Orthis occidentalis* and *Callopora dalei.*

157. A mile and a half southwestward down the creek, a short distance north of the railroad crossing, in a short gully, the top of the Lower Silurian limestone is found 24 feet above the base of the creek. It contains concretions, enclosing fragments of *Orthis.* Clay, one to two inches thick, intervenes between this and the basal Niagara limestone. The latter is white and 12 to 15 inches thick. The region of the Madison-like clayey rock, five feet thick, is not exposed. Rubble limestone and clay, seven feet thick, overlie this horizon; the rubble limestone contains good fossil remains, *Spirifer niagarensis*, *Atrypa reticularis*, *Favistella*. Above this is a 12 to 15 inch layer of solid Osgood limestone.

X. MUSCATATUCK CREEK AND ITS DECATUR COUNTY BRANCH.

158. About two miles a little north of west from locality 152, south of the road, along the eastern side of a stream, there is a fairly high bank exposing the upper part—three feet—of the Madison-like, bluish and light brown clay rock which belongs at the base of the Niagara section. Above this are six feet of rubble limestone with intercalated clay beds. Then one foot of solid limestone, the Osgood limestone.

159. A little over three-quarters of a mile down the stream, west of the road, a little dry run exposes the base of the Niagara and the top of the Lower Silurian limestone within five inches of each other. The intermediate part is filled with blue clay and the Lower Silurian *Labechia.*

The Clinton is absent. Immediately above the white basal Niagara limestone occurs the Madison-like clay rock mentioned in the last exposure.

160. From Layton's Mill one mile southeastward, and then half a mile southward, the road is crossed by the Muscatatuck. The salmon-brown Clinton is here at least two feet thick. It is not all exposed. The Madison-like clay rock is two and one-third feet thick; the rubbly limestone is four and one-half feet thick.

161. A little over two miles down the creek, northeast of the junction of a small creek with the Muscatatuck, the salmon-brown Clinton varies from one-third to one foot in thickness. Beneath the Clinton are four feet of white Lower Silurian limestone, with plenty of fossils.

162. A mile and a half southwest of this locality the Muscatatuck crosses the county line. A mile south of the line the Muscatatuck is joined by a stream from the east. A little over a mile up this stream, the salmon-brown Clinton is exposed at a very low fall; it is 20 inches thick. The Clinton contains pebbles of white limestone 6 to 8 inches long, but very flat, containing Lower Silurian fossils, among others, *Strophomena alternata*. Beneath the Clinton lies the white Lower Silurian limestone, which furnished the pebbles.

A short distance down stream, north of the road, the salmon-brown Clinton varies from 18 to 30 inches in thickness. Its uneven base rests on white Lower Silurian limestone containing *Strophomena alternata*.

163. A mile down the stream, along the roadside on the southern bank, the top of the Lower Silurian is 22 feet above the creek. The upper layer is very white, and contains plenty of fossils within two or three inches of the top. Above this is the salmon-brown Clinton, 12 inches thick; then the Madison-like clay rock, four feet; the rubble limestone, four feet; an eight-inch layer of solid Osgood limestone; five feet higher up the base of the Cliff rock or Laurel bed is reached.

164. Three-fourths of a mile westward, directly west of the angle where the road turns south, but on the western side of the stream, in a sort of gully, the Lower Silurian is well exposed. The upper layers are composed of white limestone, containing many fossils, especially *Strophomena alternata*. The Clinton is absent. Directly above the Lower Silurian occurs the base of the Niagara, a light brown limestone, one and one-half inches thick; followed by the Madison-like clayey rock, four feet thick; the rubbly limestone, three feet three inches thick, containing specimens of *Orthoceras*; a clay bed 15 inches thick; eight feet of limestone, the Osgood limestone not being distinguishable from the base of the Cliff or Laurel bed.

[illegible] belongs to the [illegible] bed.

JENNINGS COUNTY.

Y. BIG GRAHAM AND OTTER CREEKS.

165. From Benville, in Ripley County, the road goes west, then north, then west again to the Big Graham. The salmon-brown Clinton is here only one inch thick. It contains numerous small pebbles, and is underlaid by four inches of a hard, bluish, Lower Silurian limestone.

166. Half a mile down the creek, on the south bank, there is a good exposure where a dry run enters from the north, the water, in wet weather, falling down the steep banks of the creek at its junction with the latter. The farm house of William Ransdall lies northwest of the locality. Near the creek level, and for four feet above, lies the soft, bluish, argillaceous limestone, lithologically similar to the beds containing *ostracods* near New Marion. The top of the Lower Silurian is clayey and full of loose fossils. The Clinton is absent. The base of the Niagara is 16 feet above the creek. It is a 16-inch layer of white limestone. Above it lie nine feet of clayey shale, the Lower Osgood clay. Above this are three and one-half feet of Osgood limestone, then three and one-half feet of the Upper Osgood clay; above this the Cliff rock or Laurel limestone begins.

A good exposure of the Laurel limestone occurs at the bridge east of San Jacinto, three miles down the creek.

167. From Nebraska, a quarter of a mile southward, a quarter westward, a mile southward, half a mile east, the road leading southward to a large quarry in the Laurel formation is reached. South of the same, along a road leading down into the creek valley (Otter Creek), a good exposure of the rocks of this reigon is reached. From the creek to the top of the Lower Silurian the distance is 57 feet. Lower Silurian fossils occur near the summit of the formation. The top is formed by two to four inches of blue clay and one and one-half inches of hard clay rock. The Clinton is two to three inches think, the exact amount not recorded. It contains pebbles. Above the Clinton are nine and one-third feet of Lower Osgood shaley clay, there being an indurated layer, four inches thick, twelve inches above the base of the clay. The upper part of this clay contains very irregular lenses of rubble limestone with fossils. These limestone lenses become more numerous northeastward, and form the rubble limestone immediately beneath the Osgood limestone. At the present locality the solid Osgood limestone is 24 inches thick, and consists of several layers with thin clay partings, containing loose fossils. Above are 22 inches of Upper Osgood clay, then nine and one-half feet of softer white limestone, the best quarry rock, 23 feet thick, beginning above this level. All of the white limestone above the Upper Osgood clay belongs to the Laurel bed.

168. From the last locality, one and one-half miles west, one mile south, nearly a mile west, and then south to the creek road, a small rock exposure is found southwest of the road junction. The first good exposure, however, is found half a mile further southwest, where a stream crosses the road under a culvert. The fossiliferous Lower Silurian is well exposed east of the road, a short distance down the stream. The Clinton is absent. The clay rock forming the base of the Niagara again contains fossiliferous limestone masses near the top. It corresponds to the Lower Osgood clay, and is ten feet four inches thick. Over it lie 34 inches of solid Osgood limestone; then 16 inches of clay. The Osgood clays and limestone form the face and banks at the side of a small fall. Below the culvert the Cliff rock is exposed.

169. Half a mile westward, then half a mile southeastward, just before reaching a bridge across Otter Creek, in a small run west of the road, the Madison-like clay rock is exposed considerably. Higher up the Laurel bed has been quarried. The level of the Clinton is not exposed. This is a part of the Harvey Weeks farm.

170. A mile westward, northwest of the old Robert Whinnery farm, Otter Creek is crossed by a road. East of this road, on the north side of the creek the Lower Silurian is well exposed. The upper two inches are formed by white limestone, containing *Orthis biforata*, *Protarea vetusta*, etc. Below this white limestone is clay with loose fossils. The Clinton is absent. The basal Niagara consists of white limestone two to three inches thick, with minute crinoidal remains. Above this occur 11 feet of rock corresponding to the Lower Osgood clay; the lower half resembles the Madison clay rock, the upper half is more shaly. The Osgood limestone consists of 12 inches of clayey limestone, 12 inches of crinoidal limestone, eight inches of limestone, four inches of blue clay, 26 inches of limestone layers with thin clay partings. Above this is a partly indurated, irregular breaking clay bed, above which occurs the undoubted Cliff rock or Laurel bed, which is here quarried.

Z. BRUSH, FINCH AND LEATHER CREEKS.

171. About a mile north of Nebraska a small branch of Brush Creek crosses the road. Some distance down the branch the Lower Silurian is exposed, full of fossils; the top of the ordinary limestone beds is five feet above the creek. Above this is a layer of crystalline limestone containing *Tetradium*, and therefore also of Lower Silurian age. The Clinton is absent. The base of the Niagara consists of light brown limestone; six feet higher up, over the clay rock, is limestone with *Pisocrinus gemmiformis*.

172. An excellent exposure is found a quarter of a mile farther north, where another smaller branch of Brush Creek crosses the road,

flowing southward. The Lower Silurian, full of fossils, occurs west of the road. The crystalline limestone, with *Tetradium*, again forms the top of the Lower Silurian. On the west side of the culvert the *Tetradium* layer is seen to be overlaid by blue clay, which is followed by the base of the Niagara. The lower one to one and a half inches of the latter is white and crinoidal limestone. The Clinton is absent.

173. A mile westward, where Brush Creek is crossed by another road, there is an exposure on the north side. Three feet of the bluish argillaceous limestone, containing ostracods at New Marion, is overlaid by one foot of limestone containing *Tetradium;* four and one-quarter feet of Lower Silurian rock containing, near the top, oölitic concretions enclosing fragments of *Orthis*. The oölitic concretions are again seen higher up, 18 feet above the creek. The concretions vary from one-fourth to one-third inch in size. Overlying the upper bed is the crystalline limestone layer, eight inches thick. The Clinton is absent. The base of the Niagara contains *Pisocrinus gemmiformis.* Farther up the road are found five feet of shaly limestone, overlaid by more solid limestone beds of Laurel or Cliff rock age.

174. A mile northwest of locality 172, on the road from Nebraska to Zenas, Finch's branch is reached. A quarter of a mile up stream, on George Lohse's farm, east of Mike Spoeleder, there is an exposure on the east side of the branch, near the base of the low hill land. About six feet above the branch occurs Lower Silurian limestone with oölitic concretions. Above this is a 12-inch layer of limestone with *Tetradium.* This is followed by a 12–15-inch layer, also with concretions. Above this are three feet of thin fragmental limestone with fossils, followed by a clayey layer containing *Labechia.* Above this occur four to ten inches of salmon-brown Clinton limestone, full of white limestone pebbles, the largest being four inches in length. The base of the Niagara is argillaceous, light-brown limestone.

Farther up the stream the Clinton was absent. The *Labechia* layer was overlaid by Niagara limestone containing *Holocystites* and *Pisocrinus gemmiformis.*

175. A mile northward Leather Creek is reached, a short distance south of Zenas. Less than a mile up this creek is a good vertical bank exposure, 20 feet high. It begins with the upper part of the Madison-like, clayey rock, followed by the rubble limestone, then a solid bed of white Osgood limestone, ending with 15 inches of soft clay. This is followed by 12–15 feet of white Cliff or Laurel limestone.

176. Half a mile east of Zenas, the stream, after flowing southward, makes an abrupt bend westward. At the angle a small stream enters Leather Creek from the east. It forms a considerable fall within sight of the road. The ordinary Lower Silurian limestone along the creek is seven feet thick. It is overlaid by the *Labechia* layer. The base of the

Niagara consists of four inches of solid limestone; this is overlaid by four feet of Madison-like greenish and light brown clay rock; four feet of rock, clayey below, turning into a rubble limestone above; 12 inches of Osgood white limestone with crinoidal remains and *Illænus insignis;* 15 inches of soft clay; 22 feet of Cliff or Laurel limestone.

177. A quarter of a mile east of Zenas, where the road, after going south down the stream, turns westward toward Zenas, the top of the Lower Silurian is exposed 10 feet above the creek level. It consists of solid limestone, the upper part with concretions overlaid by six inches of clay, with *Tetradium*, *Labechia* and thin limestone fragments, with ordinary Lower Silurian fossils. The Clinton is absent. The white basal Niagara limestone is 12 inches thick. Further up stream about seven feet of light brown limestone with intercalated clays are exposed. This is followed by four inches of limestone with *Pisocrinus gemmiformis*, the same fossil occurring again in a layer of limestone four feet higher up.

AA. SQUAW AND MUSCATATUCK CREEKS.

178. On Squaw Creek, a quarter of a mile north of the county line, the steep east bank shows 12½ feet of Lower Silurian rock, consisting of clayey limestone, full of fossils, weathering into small fragments; over this are four feet of white Lower Silurian limestone with *Strophomena alternata.* The Clinton is absent. The Madison-like clay rock is three and one-fourth feet thick; the rubble limestone is here replaced by thin-bedded even limestones four feet thick. The Osgood limestone is eight inches thick.

179. In a gully half a mile southward, south of the next road crossing the creek from the west, the white limestone at the top of the Lower Silurian contains *Strophomena alternata*, *Orthis biforata*, branching bryozoans, etc. Above this is the Madison-like clay rock, followed by rubble limestone, the total being seven feet. The Osgood limestone is 12 inches thick. This is overlaid by 12 inches of clay, followed by 10 feet of Cliff or Laurel limestone.

180. A mile southward, in a ravine on the south side of the Muscatatuck, where it takes a westerly course, the top of the Lower Silurian is 15 feet above the creek. The Clinton is absent. The base of the Niagara is a white or light brown siliceous limestone.

181. Half a mile westward and then nearly a mile southward along the Muscatatuck, a small gully is found a short distance north of the east and west road crossing the creek at the mouth of Flat Rock Creek. Lower Silurian bowlders contain oölitic concretions. Along the road itself the top of the Lower Silurian consists of white limestone with *Strophomena alternata.* Within four inches of the same the white Niagara limestone, with *Pisocrinus gemmiformis*, occurs.

182. Nearly a mile and a half southward Wolf Creek enters the Muscatatuck. For about an eighth of a mile northward a road ascends the valley of Wolf Creek and then that of a small branch which enters Wolf Creek where it bends towards the south. The small stream exposes the Lower Silurian. The upper part of the Lower Silurian consists of three feet of blue, clayey limestone, with bryozoans, and at the top with oölitic concretions, followed by two inches of white Lower Silurian limestone. This is overlaid by 11 inches of salmon-brown Clinton, three and one-half feet of clayey limestone, a thin layer of limestone with *Pisocrinus gemmiformis*, six and one-half feet of softer clayey limestone with *Pisocrinus* at various levels, two feet of Osgood limestone, six inches of clay, one foot of limestone, 3 feet of softer limestone, and, finally, the continuous Cliff or Laurel limestone.

183. Directly east of Zenas, on the east side of the Muscatatuck, some distance north of its junction with Leather Creek, the top of the Lower Silurian is 23 feet above the creek. It is full of fossils. The upper 12 inches consist of a white limestone containing *Orthis biforata*, *Orthis occidentalis*, *Streptelasma corniculum*. The Clinton is absent. The base of the Niagara is formed by a solid, Madison-like, clayey rock.

184. Three miles down the creek a road crosses the creek and leads northward to a school house, a quarter of a mile distant. A small stream follows the road. Half way up the road, on the west side, the bed of the stream exposes the Lower Silurian. The crystalline limestone occurs near its top. The Clinton is absent. The clay and rubble stone, corresponding to the Lower Osgood clay and the Osgood limestone, are well exposed in the steep bank. Farther up stream the Cliff or Laurel limestone is exposed.

185. A third of a mile southwestward another small stream enters the creek from the north. No Clinton could be detected.

186. A mile and a half southward the creek bends towards the west. A third of a mile down the creek from this point it is crossed by a road. An exposure occurs along this road. The Lower Silurian is shown at the creek level. It consists of 20 inches of blue limestone with fossils, followed by a bed containing *Labechia* and branching bryozoans. The Clinton is absent. The lower part of the Niagara consists of Madison like clayey banded rock, 76 inches thick, followed by 32 inches of rubble limestone, 16 inches of solid Osgood limestone, 16 inches of soft clay, 12 inches of hard clay rock, overlaid by Cliff or Laurel limestone.

187. On the east bank of the Muscatatuck below its junction with Brush Creek, the rubbly Osgood limestone and the solid limestone bed with *Pisocrinus gemmiformis* are shown. About four and one-half feet higher up the base of the Cliff rock appears. The Lower Silurian is not exposed.

DECATUR COUNTY.

BB. SAND CREEK AND ITS BRANCHES.

About two miles south of Greensburg, on Sand Creek, where the pike turns abruptly westward, the Laurel limestone is quarried.

HARRIS CITY.

Nearly two miles westward, and then a mile southward, at Harris City, the Laurel limestone is again extensively quarried.

Measuring from below upwards, the following layers occur:

14 inches, cap into 2 pieces.
6 inches.
21 inches.
5 inches.
14 inches.
18 inches, cap into 3 pieces.
23 inches.
24 inches, cap into 3 pieces.
27 inches, cap into 2 pieces.
18 inches, cap into 3 pieces.
18 inches, cap into 2 pieces.
18 inches, cap into 2 pieces.
18 inches.
60 inches of various layers used for rubble.

188. About a mile south of Harris City, where a footbridge leads over Sand Creek to Parker's Mill, there is a small exposure on the south side of the creek. The salmon-brown Clinton is about seven inches thick; possibly all of it is not exposed. It contains *Illænus daytonensis*, *Strophomena tenuis* and *Leptæna* (*Strophomena*) *rhomboidalis*. Beneath the Clinton are four inches of bluish limestone, then three feet of clayey, shaly stone, the creek level being three feet lower.

189. About half a mile westward, and then half a mile southward, the creek road passes over a short hill, which exposes along the creek about 28 inches of salmon-brown Niagara. Above the Clinton are two inches of white basal Niagara limestone. Below the Clinton are at least four feet of blue, clayey, crumbling rock, the lower part shaly and containing worm burrows.

Half a mile southward to an iron bridge, a mile eastward, and then a mile southward, Gaynorville is reached. Cobb's Fork is a short distance southward. A quarter of a mile up the creek the southern banks expose a considerable thickness of Lower Silurian limestone, at least 15 feet.

190. A mile east of Gaynorville, a small stream enters Cobb's Fork from the north. Northeast of the junction of these streams a steep bank exposes Lower Silurian limestone with *Strophomena alternata*, about ten feet above the creek bed. The Clinton is absent. The base of the Niagara is a whitish, densely crinoidal rock, four inches thick.

191. A third of a mile up the creek, on the north side of the creek, just before reaching the point where the road crosses over to the north side of the creek, the Lower Silurian is exposed in the form of a bluish, shaly rock without fossils. The Clinton is absent. The base of the Niagara is four inches thick, and is a dense white limestone. The Madison-like, clayey rock is four feet thick. The softer crinoidal limestone overlying it is three and one-half feet thick. It contains *Pisocrinus gemmiformis*. Over this is the horizon of the Osgood limestone.

192. Going from Westport half a mile northeast, a quarter of a mile east, and nearly half a mile southeast, the Boicourt quarry is reached. The Laurel limestone is here extensively quarried. On the south side of the creek, opposite the quarry, the high banks expose Lower Silurian rocks, seven feet of thin limestone and clay full of fossils. The Clinton is absent. The basal Niagara is represented by one and one-fourth feet of white siliceous limestone, merging upward into Madison-like clay rock, four feet thick. Four feet of thin limestones represent the rubble limestones of more eastern sections, and a one-foot layer of solid limestone represents the Osgood limestone. The Cliff limestone is separated by only a thin clay bed.

193. The road from Boicourt's quarry crosses the creek and leads eastward up a steep hill. If, instead of following the road when it turns northward, the easterly course be continued down into Painter Creek, an exposure will be found on the eastern bank of the latter. Seven feet of Lower Silurian limestone terminate above in a layer of white limestone with *Strophomena alternata*. The Clinton is absent. The basal siliceous Niagara limestone is not distinctly demarcated from the Madison-like clay rock above. The thin limestone layers, the Osgood limestone and the Laurel limestone also grade into each other.

194. Half a mile southward, along the next road crossing Painter Creek, the eastern bank exposes about 15 feet of Lower Silurian rock; the upper five feet are clayey and are full of Lower Silurian fossils. Below this are three feet of blue limestone. There is no Clinton. The basal Niagara limestone is a siliceous, brownish rock. Above this are several feet of Madison like clay rock. The Osgood limestone, several feet farther up, contains *Stephanocrinus osgoodensis*. The Laurel bed is found immediately above.

195. A mile down the valley, on the south side of Sand creek, opposite the crossing of a north and south road, the Lower Silurian blue limestone is exposed low down, a little above the creek level, in a little run.

196. Half a mile down the creek the Lower Silurian has disappeared and even the base of the Laurel formation almost reaches the creek level.

197. Directly south of Vernon, opposite a cemetery, is the beginning of a tunnel which leads from one part of the Muscatatuck to a part considerably farther down its course, but owing to the bend in the creek, only a few hundred feet distant from the upper end of the tunnel. A mill at the southern end of the tunnel is known as Tunnel Mill. In the stream below the tunnel, on the south side, the upper part of the Laurel limestone is exposed. The lowest part of the exposure consists of three feet of solid white limestone. Over this are six and a half feet of rubble limestone with chert nodules and intercalated chert layers and 20 inches of solid limestone. Next follow eight inches of indurated clay rock, and 49 inches of Waldron shale, full of fossils. These layers have been penetrated by the tunnel and many beautiful fossils have been collected here, especially by Mr. J. F. Hammel and other geologists at Madison and Hanover, Indiana. Overlying the Waldron shale are 40 inches of hard, clayey limestone; 40 feet of Upper Niagara limestone, most of it dolomitic and of a light brown color; 10 feet of Corniferous limestone, full of corals, nine feet not exposed; three feet of Corniferous limestone, full of brachiopods; a 12 inch layer of limestone, with brachiopods and fish teeth; 12 inches of Waterlime, a dense blue limestone; a 16-inch layer of the Devonian crinoidal layer, with fossils; and 25 feet of black shale. The section above the Waldron shale was taken by ascending the road eastward from the southern mouth of the tunnel and thence northeastward towards Vernon.

The Tunnel Mill south of Vernon lies 7½ miles northwest of Dupont and 12½ miles north of Paris Crossing. It lies 22 miles south of the Waldron shale localities near Hartsville, in Bartholomew County, 33 miles south of St. Paul, 36 miles south of Waldron in Shelby County, and 37 miles south of the Waldron shale locality near Moscow in Rush County. The total distance between the Paris Crossing locality in Jefferson County, and Moscow in Rush County, is 50 miles.

ROCKS ONCE QUARRIED WHICH HAVE PROVEN TO BE USELESS OR OF INFERIOR VALUE.

All extensive quarries in Lower Silurian rocks in southeastern Indiana have proven to be failures. While the thinner limestones are often used for cellar walls, the thicker ledges have turned out to be not durable when exposed to the weather.

The gasteropod layer was extensively quarried by Dean at Marble Hill in 1853. Within five years from that date it was abandoned. The stone is a fairly pure limestone, containing 92 per cent. of the carbonates of lime and magnesia, the latter occurring in only small amounts. The deposit consists chiefly of detrital fragments of gasteropod shells and of other rounded remains. The cement is more argillaceous and will not withstand the influences of weathering. The result is that when the stone is exposed it soon begins to crumble. Even for interior work it proved unsatisfactory, and the use of the rock has been entirely abandoned.

The Madison rock contains over 50 per cent. of carbonate of lime and about 3 per cent. of carbonate of magnesia. It may therefore be called an impure limestone in spite of the fact that the old analyses give 20 per cent. of silica and 15 per cent. of alumina. It is an argillaceous limestone. The stone was at one time considerably quarried in the immediate vicinity of Madison, and shipped by steamer to various points along the Ohio. It was found, however, to disintegrate quickly. The court house at Louisville, erected from this stone, already looks like a very old building. The quarries have been abandoned for a long time.

Along Cæsar's Creek, between Versailles and Osgood, several thick ledges of blue, fine grained Lower Silurian limestone, within 40 feet of the top of the Lower Silurian, were quarried for a time. They did not withstand weathering, and the quarries have been abandoned.

The Osgood limestone is quarried immediately north of Osgood, and at a few other localities. It is inferior in quality to the Laurel limestone. Owing to the comparatively small thickness of the Osgood limestone section, and to the presence of the much superior Laurel limestone, often in its immediate proximity, the Osgood limestone can not compete with the latter. It is burnt for lime north of Osgood, but the lime does not contain enough carbonate of magnesia to form a good quality of lime. It becomes brittle when used for mortar within a short time, and other kinds of lime are preferred by plasterers. It, therefore, can have only local value.

ROCKS WHICH HAVE AN EXTENDED USE.

THE LAUREL LIMESTONE.

The Laurel limestone is a very fine quality of building rock. It is extensively used for this purpose in Ohio and Indiana, especially at Dayton, Ohio, where the stone is frequently employed to heighten the artistic effect of various public and private buildings. Sometimes entire buildings are constructed of this stone, the pure white color of the rock producing a noble impression, when seen in a massively constructed building.

Chemically, the rock contains about 90 per cent. of the carbonates of lime and magnesia, the better qualities of stone containing only six per cent. or less, of the carbonate of magnesia, although it sometimes forms 10 per cent. of the rock.

The rock occurs in layers which in the immediate neighborhood of any one quarry, preserves a very constant thickness. The different layers in the same quarry vary considerably in thickness. Five, six, seven, eight and nine inches are the more common thicknesses of layers, and layers of this thickness can be secured in almost any quarry. Ledges three and four inches thick are less common in good quarries, but one or more ledges of this thickness occur in almost any quarry, so that most quarries can furnish stone having these dimensions, if desired. In addition to this, nearly all quarries have at least one layer about 16 inches thick. Usually there will be several layers at different levels, varying between 13 and 16 inches in thickness. Ledges 18, 21, 23 inches thick rarely occur oftener than once in any single quarry. Layers thicker than two feet are exceedingly rare, and it is questionable whether these layers will bear a great pressure parallel to the bedding without splitting. The mere fact that a layer of stone can be quarried out into a piece 36 inches thick, as at New Point, does not signify that it is safe to use thickness of this kind for vertical positions where the strain comes parallel to the bedding. Three feet is the greatest thickness cited in the case of any layer of this limestone anywhere in Indiana.

The report on Decatur County, in the Twelfth Annual Report of the Indiana Geological Survey,* is of especial value, for the purpose of securing a good idea of the various thicknesses of the layers of Laurel limestone in that county.

In the body of that report, in connection with the description of the quarries at New Point and Osgood, the thickness of all the layers quarried is recorded. The thickness of the layers at the Harris City quarries is also given. The duplication of many sections of this kind at the different localities would be of no geological value, although of considerable commercial interest. The New Point and Osgood localities are, however, practically the only quarries worked upon any considerable scale, east of the Decatur County quarries along Sand Creek and elsewhere.

During the progress of the investigations included in the present report the writer had constantly in mind the possibility of favorable locations for quarries on a considerable scale, similar to those along Sand Creek in Decatur and northern Jennings County.

The most southern range of localities favorable for the development of new quarries lies along Big Creek, beginning at the Reuben Walker bridge and extending thence up the creek for a distance of three to four miles.

Along the Little Graham, for several miles below New Marion, quarries could be opened, but the layers seem mostly not to exceed six to eight inches in thickness, and many are thinner.

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* 1882.

Fine quarry stone is again seen at the bridge over the Big Graham at San Jacinto, and thence eastward at various localities, to New Marion and Tanglewood Church.

The lower Muscatatuck, from the north of Oakdale for several miles up the creek, also exposes quarry stone.

Along Flat Rock Creek exposures of Laurel limestone are abundant, though the layers are often only four inches thick.

The neighborhood of Osgood and New Point is already well exploited for Laurel limestone, though other quarries could be readily started.

At Napoleon a number of localities could be easily quarried, although the exposures do not present a great thickness of this rock.

The districts just mentioned are the most promising for the development of considerable belts of quarries, similar to those along Sand Creek in Decatur County.

The layers of Laurel limestone can usually be readily separated from each other along the horizontal bedding planes between the different layers When a slab has once been freed from the remainder of the rock belonging to the same sheet, it usually can be readily lifted off from the layer below.

In some cases the various layers are cut by very narrow seams. Not uncommonly two sets of seams crossing nearly at right angles are present in the same quarry. Where this is the case, wedges may be introduced along these seams, and advantage may be taken of their presence to secure large slabs of stone without first cutting the rock or loosening it by closely set drill holes.

In those quarries which are not well traversed by seams it is necessary to drive rows of holes into the various layers and then wedging off layers of desired size. For this purpose hand drills are used, but the larger quarries employ steam drills. At New Point, for instance, the required length and width of any slab is secured by placing rows of closely set drill holes along the lines where it is desired to wedge off the stone, and then employing the wedges. The Sullivan channeling machine, manufactured at Claremont, New Hampshire, is sometimes employed in order to produce a clean cut along the shorter diameter of the intended slab, and later a few holes, a foot or more apart, are produced along the length of the slabs, wedges are inserted, and the slabs are then split off.

For the lifting of stone, traveling derricks or derricks on car wheels are very useful. A derrick intended to lift three tons, at a twenty-foot radius from the track on which it rests, is manufactured by the Industrial Works at Bay City, Michigan. The derrick is of iron and cast steel, and moves along a railroad track, enabling the quarrymen to use the derrick at various points in the same quarry. The old-fashioned traveling derricks ran on forty-foot gauges, and, though built of wood, could nevertheless lift much greater weights. The old wooden derrick

[illegible]

[illegible]

THE LOUISVILLE LIMESTONE.

The Louisville limestone is quarried both as a building stone and for lime. The piers of the Louisville bridge were constructed of this stone, and the rock is naturally often used near Louisville.

Along the Ohio River between Charlestown Landing and Utica, it is chiefly used, however, for the production of lime. This lime is then sold under the name of Utica lime. The production of lime is a considerable industry along the river front. Very few quarries are worked for lime at any considerable distance from the river front. The Louisville limestone seems to change its chemical nature northward, the color northward being brownish instead of white, and the grain somewhat finer.

For further remarks on the distribution and general character of the Laurel and Louisville limestones, see the earlier part of the report, under the special description of these formations; also the various notes under the description of localities, in the main body of the report.

at the Al. Arleman quarry, southwest of Osgood, can lift about seven tons.

When it is necessary to drain the quarry the Standard Duplex Pump, manufactured by the Laidlow & Dunn Company, of Cincinnati, Ohio, will be found very serviceable where steam is used.

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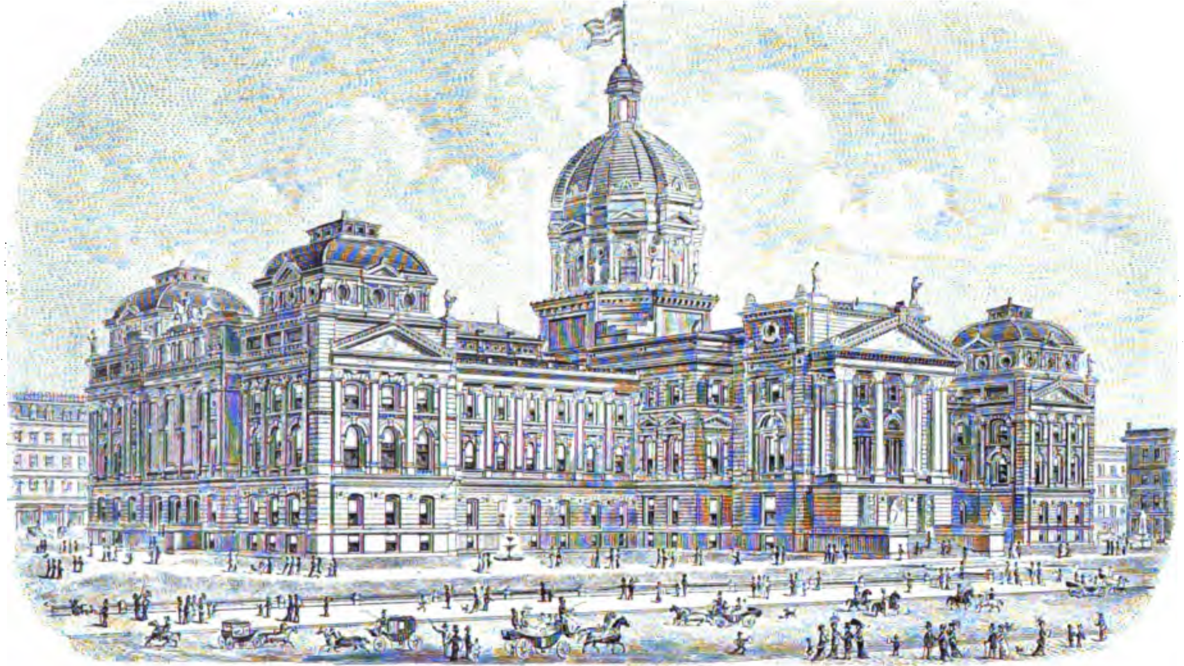

Wm B Burford, Lith Indianapolis Ind.

INDIANA STATE HOUSE.

THE

Bedford Oölitic Limestone

OF INDIANA.

A JOINT REPORT ON THE OÖLITIC LIMESTONE OF INDIANA AS IT OCCURS
IN LAWRENCE, MONROE AND OWEN COUNTIES, AND PARTIAL
REPORT ON WASHINGTON COUNTY, WITH A CHAPTER
ON THE GENERAL CHARACTER OF OÖLITES.

BY
T. C. HOPKINS
AND
C. E. SIEBENTHAL,
WITH FOUR MAPS BY C. E. SIEBENTHAL.

IN THE 21st ANNUAL REPORT
OF THE
DEPARTMENT OF GEOLOGY AND NATURAL RESOURCES.

W. S. BLATCHLEY, STATE GEOLOGIST.

INDIANAPOLIS.
1896.

LETTER OF TRANSMITTAL.

STATE COLLEGE, PENNSYLVANIA,
January 1, 1897.

DEAR SIR—I have the honor to transmit herein my report, along with that of Mr. Siebenthal, on the oölitic limestone of Indiana, prepared under your directions during the past year. It is much to be regretted that time and the means at your command did not permit the investigation and mapping of the entire oölitic area. The accompanying maps will be found, I think, valuable and reliable. They are made with greater accuracy of detail than is commonly given to maps of this character. The locations of the quarries and limits of the outcrop of oölitic stone will be found to be reliable within the limits of the scale of the map.

In accordance with your instructions the work was pursued very largely on economic lines.

Respectfully submitted,

T. C. HOPKINS.

PROF. W. S. BLATCHLEY,
State Geologist.

THE BEDFORD OÖLITIC LIMESTONE.

BY T. C. HOPKINS AND C. E. SIEBENTHAL *

INTRODUCTORY.

The Bedford oölitic limestone is probably the best known building stone in the United States at the present time. It is probably shipped to more different points than any other stone. As shown in the report, it has been used in 23 States, one territory and one foreign country. It has several rather unique features that have placed it and will probably keep it in the list among the best building stones. There is no other building stone as soft and as easily worked that is, at the same time, as durable and strong. This is due largely to the happy combination of the good properties of both sandstone and limestone, being a calcareous freestone, and also to its great homogeneity both of texture and composition. It is more easily cut and carved than any other well known building stone in this country, and it will retain the carving in good preservation longer than any other stone of equal softness.

Its general usefulness—in plain building, in ornamentation, in monuments—coupled with its lasting properties and its abundance and the ease with which it can be quarried, all combine to keep it in prominence among building stones. Naturally, then, there is a desire among stone dealers, architects, scientists and others to have access to detailed and specific information concerning the stone. To supply this demand the following pages have been prepared.

In view of the brief time and small expense that could be devoted to this subject, all the work was conducted on economic lines, and the more strictly scientific phases of the subject were subordinated or ignored entirely.

On the accompanying maps will be found the location of every quarry that has been opened in the oölitic limestone in Owen, Monroe and Lawrence Counties, showing its relative position to the railroads, the wagon

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*Mr. Siebenthal wrote Chapter I, obtained nearly all the statistics at the end of Chapter III, furnished the historical data in Chapter IV, and assisted in Chapter VI. The remainder of the report was written by the senior author. The entire report has had the criticism of both writers. The maps are the work of Mr. Siebenthal alone.

roads, streams, towns and postoffices. There is also shown the area of outcrop of the oölitic stone, where other quarries may be opened, and its relation to the overlying and underlying rocks.

Despite the wonderful development of the stone industry in this region during the past 20 years, it is but reasonable to suppose from the present indications that it will continue to increase for some years to come; because the stone is now better known than ever before and there is a demand for light colored stone and stone adapted to ornamental carving, which demand no other stone meets more satisfactorily than the Bedford oölitic limestone.

Some may criticise the report as partaking too much of the nature of an advertisement. A little contemplation will, however, convince any one that a State has not only a right but a duty to advertise her own natural resources, as the more they are known the more intelligently they will be used to the improvement of the State. The report is intended primarily for persons interested in the use or production of the stone, and to such the so-called advertising features may be not the least valuable.

By advertisement is not meant an extravagant praise of the merits while totally ignoring the defects, but the plain, candid, unprejudiced statement of such facts as will be of interest and use to persons interested in the industry, whether as producers or as consumers. This we have endeavored to do as far as possible, while at the same time endeavoring to say nothing that would compromise or make public the private affairs of any single company.

CHAPTER I.

GENERAL GEOGRAPHICAL AND STRATIGRAPHICAL FEATURES.

C. E. S.

Location. The area mapped and covered by this report includes the Bedford oölitic limestone as it occurs in Owen, Monroe and Lawrence Counties. This limestone, in the region under consideration, is exposed in a labyrinthine outcrop winding in and out the valleys and around the hills over a distance of more than sixty miles, and varying in breadth from outlier to inlier from two to fourteen miles, on the average, perhaps, five miles. It is not to be inferred that this area includes the whole of the Bedford oölitic limestone within the State, nor even all of commercial value. It is simply the ground covered within the limits of time and means at the disposal of the survey, and is inclusive for all the area north of the south boundary of Lawrence County. The quarries at Salem are not included in this area, nor the many other valuable deposits known to occur in Washington, Harrison and Crawford Counties.

The oölitic belt practically begins on the north at Gosport. The limestone is traceable north of there as far as Quincy, but at no place does it occur in commercial quantities. Southwest of Gosport it shows in the bluffs of White River to within about a mile of Spencer. Southeast of Gosport the oölitic crops out in a belt about three miles wide, embracing the quarry districts of Big Creek, Stinesville, Ellettsville and Hunter Valley and extending to Bloomington. Four miles south of Bloomington, in the vicinity of Clear Creek Station, the oölitic belt rapidly widens to six miles, due to the fact that the lower course of Clear Creek makes a broad circle to the west, cutting down through the Mitchell and oölitic limestone, thus adding the oölitic outcrop on each side of the creek to the original outcrop of that limestone.

The great width of the outcrop in Lawrence County is due to similar causes. The lower course of Salt Creek and that part of White River from Tunnelton to the mouth of Salt Creek both lie several miles west of the eastern crop of the oölitic limestone, but have cut their valleys down through both the Mitchell limestone and the oölitic limestone. The various creeks from the east—Little Salt, Pleasant Run, Leatherwood and Guthrie creeks—also cut down through the oölitic, and what would otherwise be a plateau is divided into a number of flat ridges capped with Mitchell limestone, but fringed with a band of outcropping oölitic limestone.

The oölitic belt, after passing out at the southeast corner of Lawrence County, swings eastward to Salem, Washington County, taking in the Salem quarries and Spergen Hill. Thence it swings southward, its westward limit following the lower course of Blue River to the Ohio, and its eastern limit taking in the quarries at Georgetown and Corydon.

Topography.—The dip of the Subcarboniferous rocks over the region herein described is from 50 to 60 feet to the mile in a direction south of west. This dip does not seem to have left any impress on the topography of the region *other than the initial direction of the drainage.* The topographic features of the area owe their existence to the inherent qualities of the different formations. Thus the incoherent, loosely-cemented, easily-eroded knobstone has been cut up into a confused tangle of crooked ridges and deep hollows which trend in all directions. The topography of that part of the Harrodsburg limestone area which borders the knobstone partakes more or less of the character of the knobstone topography, though the ridges are larger as a rule. As for the remainder of the Harrodsburg limestone area, whether or not it is deeply eroded and broken depends on its distance from White River, and the height of its drainage level above the baselevel, which is the level of White River. This may readily be seen in the vicinity of Bloomington, at a point two miles east of that city on the divide between Bean Blossom and Salt Creeks. The distance north to Bean Blossom Creek is five miles, the distance east to Salt Creek four miles, and the distance to Salt Creek by way of Jackson and Clear Creeks is sixteen miles. The result is manifest in the topography. Northward and eastward from the divide the hills are rugged, the hollows crooked and deep. Southward, down Jackson Creek, the surface is but gently rolling.

The oölitic limestone, being the thinnest of the Subcarboniferous formation, has no particular type of topography. It usually occurs as a narrow outcrop from 100 to 400 yards in width fringing the flanks of the hills. Where it forms the surface rock over any extent of territory, as it sometimes does, when it makes the cap rock of a wide ridge, the topography is gently undulating.

The Mitchell limestone, where it has superficial drainage and especially where it has a capping of the Kaskaskia sandstone, forms high, bold hills with wide, well-rounded valleys between. Where the drainage is subterranean, the result, of course, is an irregular undulating plateau.

The valley of White River at Gosport is 570 feet above sea level. The river hills rise 100 to 150 feet above the valley, and the crests gradually rise southward, until in the vicinity of Bloomington along the divide between the two branches of White River, the hills reach 900 to 950 feet in elevation. The highest points in Monroe County range themselves between these elevations. The valley of the east fork of White River, south of Bedford, is 500 feet above sea level. The highlands about Bedford range from 700 to 750 feet in elevation, and those about Mitchell, something near the same. The crest of the ridge, which marks the eastern escarpment of the Kaskaskia group, approximates 800 feet in height.

Nomenclature.—The term Subcarboniferous, as first used by D. D. Owen,* was undoubtedly applied to the whole series of sedimentary rocks which lie beneath the Coal Measures of Indiana. Later, in 1844, he restricted its application in a somewhat indefinite way to the lower calcareous division of the Carboniferous.†

In 1852 the name was definitely applied to the lower division of the Carboniferous rocks and included the Carboniferous limestones of the Mississippi section. In a paper entitled "Researches among the Protozoic and Carboniferous Rocks of Central Kentucky," published in 1847 by D. D. Owen and J. G. Norwood, the Knobstone is referred to the Carboniferous. Finally, in the revised reprint of D. D. Owen's Geological Reconnoissance of Indiana, the Subcarboniferous is specifically designated as "a series of limestones with subordinate fine-grained sandstones and shales" lying between the Coal Measures and the Devonian black slate;‡ and it is as thus limited that the term Subcarboniferous has been since used in the reports of the geological surveys of Indiana, Illinois and Kentucky.

The word has been objected to as having been applied under a misconception and as being a misnomer. As to the first objection, we have seen how that misconception was cleared up and how the term was sanctioned by general use afterward. The second objection arises from a misunderstanding of the meaning of the term in its restricted application. So used, it means not "under the Carboniferous" but "the under-Carboniferous," or, according to J. D. Dana,|| the preposition *sub* is used in the same sense as in the word *substructure.* It was with this meaning that James Hall applied the term independently to certain beds of limestone intercalated in the Knobstone whose fauna he recognized as Carboniferous, yet which he wished to distinguish from the later Carboniferous.§ So it is that in preference to the various synonyms, Lower Carboniferous, Mississippian and Eocarboniferous, which have been proposed, we have retained the Subcarboniferous out of justice and respect to the memory of Indiana's first and greatest geologist.

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*D. D. Owen: Report of Geological Reconnoissance of Indiana, made in 1837. 1839 p. 12.

†D. D. Owen: Report of a Geological Exploration of a part of Iowa, Wisconsin and Illinois in 1839. Senate Document, 407, 1844.

‡D. D. Owen: Report of a Geological Reconnoissance of Indiana, made in 1837; reprinted, 1859.

||J. D. Dana: Manual of Geology, 4th edition, p. 634.

§James Hall: Notes explanatory of a Section from Cleveland, Ohio, to the Mississippi river in a southwest direction, with Remarks upon the Identity of the Western Formations with those of New York. Trans. Assoc. Am. Geol. and Nat.; 1840-42, pp. 267-293.

Stratigraphy.—The Subcarboniferous deposits, as generally recognized in Indiana, include the Rockford Goniatite limestone, the Knobstone group, the Harrodsburg limestone, the Bedford Oölitic limestone, the Mitchell limestone and the Chester and Kaskaskia group.

The Rockford Goniatite Limestone was first noticed by Owen and Norwood in their paper on the Protozoic and Carboniferous rocks of central Kentucky, and referred by them to the Devonian. It is a thin bed of limestone and calcareous shale of limited areal extent, coming between the Devonian black shale and the Knobstone and furnishing the famous fossils which led, after much controversy, to its recognition as the base of the Carboniferous.

The Knobstone was originally included by D. D. Owen with the Harrodsburg limestone under the name Calcareo-siliceous or Encrinital limestone series.* The use of the word Knobstone to designate the formation first occurred in 1859 on page 21 of the revised reprint of Owen's report then issued. The name was again used in 1862 by Richard Owen,† and has been retained by the various writers on Indiana geology since that time. It is a series of alternating friable arenaceous shales and sandstones, ranging in the region under consideration from 500 to 600 feet in thickness. The outcrop reaches its maximum development in Hendricks, Morgan, Brown and Jackson Counties, in which region it ranges from 30 to 50 miles in width. The outcrop narrows rapidly both north and south of this area. It is in the main unfossiliferous, but at intervals there are intercalated lenticular beds of limestone and calcareous septaria with rich faunas, and in one place at least the Knobstone itself is fossiliferous. The name is derived from the peculiar topography which it superinduces in regions where fully developed, as in the "knobs" of Floyd and Clark Counties. The use of a topographic term as a designation for a geological formation is rather unfortunate, but in view of its firm establishment and the fact that it is more or less probable that the formation may in the future be subdivided leads us to retain it in this report.

The Harrodsburg Limestone lies above the Knobstone and between that formation and the Bedford oölitic limestone. At first known as the Encrinital limestone, it was afterward correlated with the Burlington and Keokuk limestone of the Mississippi section. These formations have latterly been grouped together in the original locality as the Augusta limestone.‡ Until more detailed palæontologic work has been done in Indiana it would seem better to consider the formation a unit. We have designated it the Harrodsburg limestone, taking the name from the village of that name on the L., N. A. & C. Ry., in the southern part of Monroe County, where this limestone is typically developed. The village itself is mainly built upon the oölitic limestone, but near its contact with the Harrodsburg limestone, and descending the hill from the village either north, east or south, one passes over the whole outcrop of the latter from its contact with the oölitic to its contact with the Knobstone.

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*Geological Reconnoissance of Indiana, 1837, p. 14.

†R. Owen; Report of Geological Reconnoissance of Indiana made in 1859 and 1860, published in 1862, p. 108.

‡Keyes: A. J. S., 3d Series, Vol. XXXVIII, 1889, pp. 186, 193. Keyes: Missouri Geological Survey, Vol. IV, p. 58. Keyes: Iowa Geological Survey, Vol. I, p. 59.

The following section of the north bluff of Judah's Creek at the crossing of the Bedford-Bloomington road, one mile south of Harrodsburg, is typical of this limestone. The thickness of the different strata are based on barometer readings:

Oölitic Limestone.	Feet.	Inches.
Massive fossiliferous limestone	6	0
Gray heavy-bedded limestone	16	0
Blue argillaceous shale	2	0
Limestone	0	4
Chert	0	3
Heavy-bedded blue to gray crystalline limestone	6	0
Yellow calcareous shale with geodes	1	3
Fine, heavy-bedded blue crystalline limestone	11	0
Flaggy limestone	1	0
Gray argillaceous limestone	0	10
Calcareo-argillaceous shale with bands of limestone and some geodes	18	0
Heavy limestone, weathering shaly	3	0
Calcareous shale in bed of creek	?	?
	67	8

The Harrodsburg limestone varies from 60 to 90 feet in thickness. It forms a belt four or five miles in width lying along the eastern outcrop of the oölitic, rising gradually toward the east at the rate of 50 or 60 feet to the mile, and bordered by the broken hills of the Knobstone region.

The "beds of passage" from the Knobstone to the Harrodsburg limestone contain great numbers of geodes, or, as they are more familiarly termed, "mutton heads," ranging from the size of a pea up to 18 or 24 inches in diameter. These geodes are confined to the lower members of the Harrodsburg limestone, though a few are scattered through the Knobstone.

Above the geode layers there is a bright gray or blue highly crystalline and quite fossiliferous limestone with small crystals of pyrites, giving it in places a greenish tint. Many of the bedding planes are marked by "crowfeet" (stylolites), and intercalated lenticular masses of chert are very plentiful. The residual clay is very stiff and of a deep-red color.

Towards the top of the limestone the strata become more massive, and at the top the upper four to eight feet usually have lost the molluscan character of their fauna and consist almost wholly of comminuted bryozoa. In places these more massive strata are quarried in a small way as marbles. On a polished bedway face the delicate tracery of the bryozoa comes out with a very pretty lace-work effect, but the porosity of the stone prevents its taking a high polish, so that it could not justly be classed as a true marble. The value of some of the more crystalline strata which would take a good polish is lessened by the disseminations of crystals of pyrite, siliceous fossils and nodules of chert.

The contact of the Harrodsburg and oölitic limestones is almost always marked by a bad crowfoot (stylolite), with which are associated masses of silicified oölitic fossils and black siliceous masses.

The Bedford Oölitic Limestone.—The term "oölitic" was first applied in Indiana by D. D. Owen to the whole series of limestones from the Knobstone to the Coal Measures.* The name had been previously applied by G. Troost to limestones in Tennessee, to which those of Indiana were supposed to be analogous. In the revised reprint of Owen's report† the name is retained, but its application is restricted to a subordinate member of the Subcarboniferous limestone—in reality, to the present quarry bed, the Bedford oölitic limestone—and its age is carefully distinguished from the oölitic of Europe, which is a well-marked group in the Mesozoic.

The name "Bedford rock" first occurs in Richard Owen's report.‡ By other writers it has been variously called Bedford stone, Bedford oölitic stone, Indiana oölitic stone, Spergen Hill limestone, White River stone, St. Louis limestone, Warsaw limestone, etc. It is probably best known to the trade as the Bedford stone, but as Bedford itself is situated on an overlying stone, it seems better to include the word oölitic to specify more particularly the bed of quarry limestone. Bedford oölitic limestone is thus a definite geological term and a well-known commercial one.

The economic character of the present report has precluded anything of a paleontologic nature, but the fauna of the Bedford oölitic limestone will be found fully treated by James Hall* and R. P. Whitfield|| in their various papers on the famous Spergen Hill fossils. In favorable localities the oölitic limestone is found crowded with miniature *Brachiopoda*, *Gasteropoda*, *Lamellibranchiata* and pentremites, all in a splendid state of preservation.

The Mitchell Limestone.—Overlying the oölitic limestone is a series of impure limestones, calcareous shales and fossiliferous limestones aggregating from 150 to 250 feet in thickness. We have called this formation

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* D. D. Owen, Geological Reconnoissance of Indiana, 1839, pp. 12, 13.

† D. D. Owen, Geological Reconnoissance of Indiana, 1837; reprinted 1859, p. 21.

‡ R. Owen, Report of Geological Reconnoissance of Indiana made in 1859 and 1860; published 1862, p. 137.

|| James Hall, Transactions Albany Institute, Vol. IV, 1856, pp. 4-34. James Hall, Geology and Natural History of Indiana, Twelfth Report, 1882, pp. 319-375. R. P. Whitfield, American Museum of Natural History, Bulletin 3, 1882, pp. 42-94.

the Mitchell limestone, taking the name from the town of that name in Lawrence County at the crossing ot the L., N. A. & C. and B. & O. S. W. railways. This limestone is well developed about Mitchell, which is situated upon it, but especially is its peculiar topography typically shown in that locality. The topographic *tendency* of the Mitchell limestone expresses itself in plateaus perforated at short intervals by sink holes. For this reason it has been called the cavernous limestone by early writers, and by others the barren limestone, because of tracts which were largely covered with residual chert fragments which have weathered out of the limestone. The lower members of this formation constitute the so called "bastard limestone" stripping of the quarrymen. They are unfossiliferous and of a dirty yellow or gray color. Above these come shales with interbedded, dark blue, heavy flaggy limestone and gray lithographic beds. Specimens of the lithographic stone have been found which worked almost, if not equally, as well as the Bavarian stone, but as yet no locality has been discovered where they can be obtained in commercial quantities. The stone is usually so intersected at short intervals by calcite seams that no stones of size can be obtained. What search may discover can not, of course, be foretold.

At different horizons in the Mitchell limestone the stone is fossiliferous. In some places it is as truly oölitic as the Bedford stone. Such oölitic limestone may be distinguished from the Bedford oölitic by the fossils, and usually by a peculiar weathering under atmospheric agencies, in which a coating of between one-eighth and one-fourth of an inch scales off or exfoliates with a peeling effect. The following section in Section 13, 7 north, 2 west, is typical of the Mitchell limestone:

Detailed Section of the Mitchell Limestone, R. 7 N., T. 2 W., Sec. 13.

Drab lithographic limestone, *L. proliferum*, in top layer	20 feet.
Chert breccia, rotten lithographic groundmass	8 feet.
Bluish-drab, fine-grained, fetid limestone	10 feet.
Lithographic limestone	4 feet.
Drab calcareous clay shale	9 feet.
Drab, rotten, magnesian limestone with chert inclusions	29 feet.
Bluish, vermicular, shaly limestone	2 feet.
Drab calcareous shale	4 feet.
Rotten and shaly lithographic limestone	5 feet.
Lithographic limestone	2 feet.
Rotten lithographic limestone	5 feet.
Drab calcareous shale	7 feet.
Fine-grained, bluish-gray limestone with conchoidal fracture	5 feet.
Calcareous clay shale	2 feet.
Gray limestone in 8-inch beds	5 feet.
Fossiliferous shaly limestone	14 feet.
Concealed	6 feet.
Fossiliferous coarse-grained limestone	2 feet.
Oölitic limestone	— feet.

The *Chester* or *Kaskaskia Group*, as recognized by Mr. E. M. Kindle, in Orange and Martin Counties consists of the Upper, Middle and Lower Kaskaskia limestones, separated from each other by the Upper and Lower Kaskaskia sandstones.* Overlying the Kaskaskia is the Mansfield sandstone, the basal member of the Coal Measures.

QUATERNARY. The *Quaternary* deposits of the region under consideration are of three classes: Glacial till and drift, pleistocene lacustral and terrace deposits, and alluvial floodplains.

Drift Limit. The line of the southernmost limit of glacial drift enters Monroe County from the southwest near where the Ellettsville and Spencer road crosses the Monroe-Owen county line. It bends south around the limits of the Flatwood, then angles northeast, crossing Jack's Defeat Creek in the neighborhood of the old Dutch church. Continuing in the same direction it crosses Bean Blossom Creek near the mouth of Cowden Branch. Bending south of the Lost Ridge near the mouth of Indian Creek, it follows the course of that creek to Canada Gap, and on it in the same direction passing one half mile south of Godsey P. O., and crossing into Morgan County three-quarters of a mile east of Godsey. It swings southeastward and reënters Monroe County where Hacker's Creek leaves it, following up that creek to the neighborhood of Hacker school house. From here eastward the drift limit becomes harder to trace. The ice sheet must have been very thin, since the topography shows little, if any, modification. Scattered erratics are found all over the ridge dividing the headwaters of Robert's Creek from the headwaters of Honey and Hacker's Creeks. It seems probable that the foot of the ice rested on this hill, and that the drift found in the headwaters of Honey Creek was carried there by the waters resulting from the melting of the glacier. Many large granitic bowlders from one to three feet in diameter are found along the small stream leading north from Hubbard Gap in section 11 (10 N. 1 E.), and along the other tributaries of Robert's Creek. In section 2, same township, heavy deposits of sand, gravel and till lie against the hillsides. In the neighborhood of Hacker school house in section 6 of the same township the smoothing and leveling action of the glacier is plainly seen in the gravel covered plain which rises gently to the north. In the neighborhood of Godsey P. O., section 3 (10 N. 1 W.) the same may be seen. Heavy beds of till and gravel lie against the hills which border their slopes on its south. In Canada Gap, northeast corner section 9 (10 N. 1 W.), the evidences of ice occupation are plain though the quantity of drift material is very limited. The territory between Indian Creek, Bean Blossom Creek and White River displays evidences of ice occupation in many places in modified topography and deposits of till, and sand, and gravel, though on the whole the drift is very light, showing a thin ice sheet.

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*Department of Geology and Natural Resources of Indiana. Twentieth Annual Report, 1895, p. 331.

The glacial topography is well illustrated in Section 5 (10 north, 1 west) and in the southeast quarter of Section 21 (10 north, 2 west). The hills north of Mt. Tabor and between there and Gosport are covered with a heavy deposit of sand which seems to have been deposited from high water resulting from a melting ice sheet. The lower hills about Gosport have a similar deposit. North and west of Gosport the drift sheet becomes heavier, ranging from 5 to 20 feet in thickness.

Glacial striæ were observed in but one locality, and that was where the limestone had been uncovered by stripping on the west side of Kessler's quarry at Romona. The direction was S. 18° E. A vertical seam or fissure in the rock at this point, 8 or 10 inches in width, was filled with tightly packed red clay up the level of the glaciated rock where it was cut off sharply by the buff sandy till which covered the rocks on either side. The red clay of the seam gave evidence of the great pressure to which it was subjected by shearing cracks and by being slickensided along the sides of the seam. This seam is perhaps a fair average in thickness of the clay seams commonly found in the oölitic. It thus serves to give us an idea through what stretches of time the solvent and erosive agencies have been at work in producing the bothersome seams of the quarries.

Glacial Lake Flatwood.—Occupying the highest land between Ellettsville and Spencer is a level tract two and one-half miles in width by six miles in length, locally known as the Flatwoods. It is drained by McCormack's Creek, to which it gently slopes from all points of the margin except at the extreme west end, a small portion of which drains into Ellison Branch. The Flatwoods is surrounded by a rim of higher land with gaps at Ellison Branch and McCormack's Creek, and at three other points on the north, east and south, where streams head up against the Flatwoods and at the same level with them. This higher border shows evidences of glaciation, especially so on the southern side, where many erratic bowlders ranging from six to eight inches in diameter have lodged against the slope. The soil of the Flatwoods is an alternation of black mucks and white clays. A section of a well in the N. W. N. W. Section 31 (10 north, 2 west), which is typical of the district, is here given:

Soil and clay	17 to 18 feet.
Imbedded logs	1 foot.
Clay	8 feet.
Waterworn gravel	1 foot.
Blue, sticky clay	8 feet.
Limestone	

Prof. Collett* gives the following section of a well in the southeast quarter of section 26, 10 north, 3 west:

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*Geological Survey of Indiana, Seventh Annual Report, 1875, pp. 333–334.

Black mucky soil	8 feet.
Sand and fine gravel	6 feet.
Blue sticky quicksand with logs, sticks and leaves	8 feet.

Over the area of the Flatwoods several "islands" of the Subcarboniferous raise themselves above the later deposits, demonstrating the undulating character of the preglacial topography.

Prof. Collett suggests that the Flatwoods formed a portion of the preglacial channel of White River, the valleys of McCormack and Raccoon Creeks furnishing the portions connecting with the present valley of that river. A close examination of the region in question, however, shows this to be impossible.

The Pleistocene terraces of Bean Blossom Creek clearly prove the preglacial valley of that creek to have been practically as it is at present. It is impossible to imagine how it could be cut down to its present depth, while White River, into which it emptied, was running at a level approximately 150 feet higher than now, as it is alleged to have done. Moreover, the gorge of McCormack's Creek is clearly postglacial. And further, it empties into White River at least a mile below the upper end of the "narrows," whose existence it was brought forward to explain.

A more reasonable explanation of the Flatwoods is that it is the site of a shallow glacial lake. This area in preglacial times must have been a region of sink holes, with drainage largely, if not wholly, subterranean, similar to the country which surrounds it, and to the region of caves and sink holes west of Bloomington—in short, a region characteristic of the Mitchell limestone. When the glacier pushed down across these sinks, the excess of salt and sand choked up the underground outlets, and on the retreat of the ice sheet, the area was left covered by a thin sheet of water, probably from 20 to 30 feet in depth near the middle. Subsequently the drainage by way of McCormack's Creek was begun, resulting in the cutting of the gorge through which that creek finds its way to the river. The size of the drainage area and a fall of nearly 150 feet distributed over about two miles explain the steepness and narrowness of the gorge.

Pleistocene terraces occur in the valley of Bean Blossom Creek above the crossing of the drift limit. Drift deposits occur below that, but are irregular in height, and have not the level top of the terraces. The terraces range from 40 to 60 feet in height, those further up the creek being the higher. In size the terraces range from mere knolls to benches a mile wide and three or four miles long. The lower portion of these beds consists of sand and erratic gravel with sand and smaller gravel above, and over all sandy clay and loam. These terraces seem to have been deposited by the high waters which must have resulted from the melting of the glacier which covered the headwaters of the creek in Brown County, and the draining of the glacier which crossed its lower course. The various tributaries of Bean Blossom Creek have similar deposits in a small way, the materials of which are, however, of local origin. The fact that the drift material of foreign origin is confined to the valley of the creek itself, argued that it was derived from the glacier occupying the upper course of the creek.

At favorable points are found stratified deposits of banded sandy clays of variable colors with disseminated spindles and scales of ferruginous claystone and irregular concretions of calcareous claystone. These beds correspond stratigraphically to the terraces and are of the same height. They have been deposited from sluggish water out of the lime of the direct current which bore the erratic materials, and as a result they are free from gravel except some of local origin in their basal portions.

The upper portion of the drainage basin of Salt Creek was also occupied by the glacier, and as a consequence we find well marked terraces along the valley of Salt Creek, though not so extensive or so high as those along Bean Blossom. The further down the creek the lower the terraces become until the last one is reached, which is in the neighborhood of Fairfax P. O., Monroe County.

Like the hills about Gosport, those along the East Fork of White River have deposits of sand, such deposits occurring up to a height of 80 or 100 feet, and always on the side away from the current of the stream; in other words, the deposits were always made in the still water of an eddy. Secondary bottoms also occur which are possibly and probably of Quaternary age, though not of the regularity as regards height and level top of the Quaternary terraces of Bean Blossom Creek.

Alluvial floodplains.—The alluvial bottoms of the West Fork of White River above Gosport range from one to three miles in width. Below Gosport they narrow down to about a mile on the average, and two miles below Romona the foothills on either side approach within less than a quarter of a mile of each other. It was to explain these "narrows" that Prof. Collett projected the hypothetical glacial river up McCormack's Creek through the Flatwoods and down Raccoon Creek, to which reference has been made on a preceding page.

The alluvial plain of Bean Blossom Creek will average a mile in width through Monroe County. Along Salt Creek through Monroe County the alluvial plain will average about a half mile; through Lawrence County it is from three-fourths of a mile to a mile in width.

Leatherwood and Guthrie creeks have bottoms which in their lower courses are about a half mile wide.

The valley of the East Fork of White River through Lawrence County is quite narrow as compared to the West Fork, not exceeding a half mile on the average, perhaps less.

CHAPTER II.

GENERAL STRUCTURAL AND ECONOMIC FEATURES OF THE BEDFORD OÖLITIC LIMESTONE.

T. C. H.

Structural features of the Bedford Oölitic limestone.—The Bedford limestone occurs in a massive bed varying in thickness in different localities from 25 to nearly 100 feet. The bulk of the stone is free from lamination and shows very few bedding planes. On weathered surfaces on the natural outcrops the lines of sedimentation are brought out more or less conspicuously at many points. Sometimes even a shaly structure may be developed on the top of the bed. In several places lines of cross bedding are brought out quite conspicuously on the weathered surface, noticeably so on the bluffs of Big Creek a mile west of Stinesville, and on the face of the old Terre Haute quarry, half a mile west of Stinesville. (See plate XX.) The same thing is shown less conspicuously in places in a great many quarry openings throughout the region, and known among the quarrymen as cross-grain. There is abundant evidence of this nature both of the false bedding and the true bedding to show the sedimentary character of the stone. Yet, as before stated, the great bulk of the stone is massive, and in all the better class of stone shows little or no evidence of lamination or bedding except at the outcrop.

In all the outcrops and in many of the quarries there is at least one system of vertical or nearly vertical joint seams, and in most places two systems, one having a general east and west direction, the other north and south. The joint seams are rarely abundant, generally 20 to 40 feet apart. Where there is a solid rock covering over the oölitic stone the seams are generally inconspicuous features, seldom more than regular cracks in the rock mass. In a number of places, in fact in nearly all places where the oölitic stone has no solid rock covering, the weathering agencies have penetrated along the joint planes, forming irregular, cave-like openings sometimes two or three feet across. These cavities are mostly filled with clay and debris from the top (see plates XXI, XXVII), causing a great deal of waste and annoyance in quarrying, as the waste is not limited simply to the cavity, but the irregular walls cause much waste in squaring the blocks, and where the cavities are close together the irregular blocks between them can not always be divided to advantage. There is a further waste where the stone happens to be blue stone, from the fact that along the joint planes the stone is oxidized irregularly, forming a band of buff of varying width on each side of the cavity. It is hard on the channeling machine to cut across one of these cavities.

Stylolites ("*crow-feet,*" "*toe-nails*").—While ordinary bedding or lamination planes are exceedingly rare in the interior of the oölitic limestone bed at any considerable distance from the outcrop, there are what might be called extraordinary bedding planes, resembling suture joints, which, unfortunately, occur in many places, appearing on the face of the quarry as jagged dark to black lines. On each side of this line, generally more pronounced on the lower side, are jagged points extending sometimes a fraction of an inch, sometimes several inches into the limestone. The longer points, and sometimes the smaller ones, have an apparent columnar structure, with the sides nearly parallel, and frequently striated. Frequently the shorter points have a more serrated or tooth-like projection. In all cases observed, with one exception, the planes have a nearly horizontal position, as nearly horizontal and about as regular as any other bedding planes, and the teeth or "toe-nails" are generally vertical. While this is true in the oölitic limestone quarries, it is not true in all localities, as in the magnesian limestone quarries in the city of Chicago they follow quite irregular lines, in some places apparently running over little hillocks or sharp prominences. The stylolite seams are of great interest and annoyance to the quarrymen, as they probably cause more waste than any other structural feature of the rock. Because of their economic importance they deserve more than a passing notice.

The stylolites have been variously designated. Among the names which have been proposed are, *suture joints*, *crystallites*, *lignillites* and *epsomites*. The quarrymen designate them as *crow-feet* or *toe-nails* quite frequently with a harsh adjective prefixed. The most commonly accepted term among scientists is stylolite, from the Greek stylus for pen, referring to the fancied resemblance to a pen. The term crystallite, lignillites and epsomites are objectionable, as they imply an origin which is not proven. Suture joint is a very good term. Crow-feet and toe-nails will continue to be used among the quarrymen, and are very expressive and not wholly inappropriate terms.

There is a difference of opinion as to the origin or cause of the stylolites. Both Dana* and Geikie† accept Marsh's explanation that they are caused by "the slipping, through vertical pressure, of a part capped by a fossil shell against an adjoining part not so capped."

Prof. Swallow says‡ that the term lignillites was much used at one time because of its resemblance to wood, and the term crystallites and epsomites have been used by those thinking that the markings are due to the crystallization of epsom salts or some other material in this form.

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*Manual of Geology, 4th Ed., by J. D. Dana, p. 543.

†Text-Book of Geology, 2d Ed., by A. Geikie, p. 290.

‡Rep. Geol. Surv. of Missouri, 1872, pt. 2, p. 252.

The German writers offer different and (in the opinion of the writer) some more probable explanations. Quenstedt* states that they are due to the filling in of hollow spaces made in the rock while yet soft by the movements of mussel shells.

His later view was that two beds overlying one another, separated by shells and a layer of clay or marl, the two beds having a different hardness, by the pressure of the overlying mass the clay bed would be torn and the underlying and overlying beds pressed into one another, thus causing the stylolites.

Plieninger† thought that the cracks or crevices originating at the surface by the drying mud were the cause, and that the pillar-like or columnar forms could be produced by rain.

Von Cotta and Rossmassler‡ put them in the same class with the "ice needles" produced on the surface of the soil in winter.

Fallati and Quenstedt have likened the stylolites to glacial pyramids, pyramids of ice left on the surface of the glacier, or little pyramids of earth which owe their columnar structure to a small stone or shell protecting the material underneath while that surrounding is washed away by the rain in the case of the earth and by the sun on the ice.

Weiss,‖ corroborating the above, states that in his observations in a Bundsandstein formation that a foreign body like a mussel-shell or a piece of clay forms a protective covering to the drying lime particles, whereby the drizzling water has modeled out the stylolite by carrying away the material between the protected parts.

Zelger,§ after detailed work on the stylolites, announces that they are formed by the escape of compressed gases through the soft plastic mass and the later filling in of the passageways.

Gümbel states that the stylolites, particularly those from Rüdersdorf, carry on top a clay cap which without doubt has come from a clay or marl layer which marks the lower limits of the bed of stone bearing the stylolites and which is a part of the under clay layer ascending with the stylolite mass.

Zirkel** says that the stylolites remind one of the phenomenon called creeps by the English miners, in the swelling up and pressing in of the underclay of the coal into the galleries or openings made in the working until the gallery is filled by the underlying clay.

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* N. Jahrb. f. Min., 1837, p. 496, and Württemberg, Naturwiss. Jahreshefte, 1853, Vol. IX p. 71, and Epochen der Natur, 1860, p. 200.

† Württemberg, Naturwiss. Jahresheft, 1858, Vol. XIV, p. 292.

‡ Zirkel, Lehrbuch der Petrographie, 2d Ed., Vol. I, p. 535.

‖ N. Jahrb. f. Min., 1868, p. 729.

§ N. Jahrb. f. Min., 1870, p. 833.

** Lehrbuch der Petrog., Vol. I, p. 536.

It is quite probable that as the stylolites differ in appearance in different localities that they may not all be produced in the same manner. The writer is convinced from his observations in the field that at least in all places where they occur in the oölitic limestone of Indiana that they mark bedding or stratification planes in the rock. The reasons for so thinking are, (1) That they correspond with the grain or bedding of the rock, occasionally running on the false bedding, but never across the grain; (2) they are in places traceable, with no break or sharp line of division into the common bedding planes, having no evidence of stylolites; (3) there is in nearly every instance a layer of carbonaceous material, sometimes a mere film, sometimes nearly half an inch thick; (4) they are always of considerable, though not unlimited, extent; (5) a view from above shown in a few places on (the Cleveland quarry, near Harrodsburg, is one of the best illustrations) quarry floors shows water action not unlike the common bedding plane; (6) they frequently occur between the oölitic stone and the underlying and overlying beds which are not at all oölitic; (7) the cross bedding always terminates at the stylolite seam: in no instance was it observed to cross it.

The explanation of the stylolitic or tooth-like markings along this seam is not so satisfactory as the evidence of its being a bedding seam. It is quite probable that all are not due to the same cause. Some look as though they were formed by cracks in the drying of the limestone mud, and others look like a rain or spray washed surface. In fact, there is probably about such variety in the markings as one might expect to find on a surface of indurated calcareous mud, some of which dried in the sun, some of which was rain washed or spray washed in the drying; and possibly the escape of gases, as advocated by Zelger, may have acted in some places. The layer of carbonaceous material is probably due to the organisms left to die on the beach, either algæ or animal forms, or both.* It is in some instances associated with considerable iron pyrites. A microscopic examination of this material from two localities shows black bituminous matter, with no organic structure or markings perceptible.

There appears to be little or no evidence in this locality in support of Marsh's theory, as in only one locality was any noticeable proportion of the stylolites capped with fossils, and where such was the case many of the fossils were delicate gastropod shells that would quickly show any pressure, had such been brought to bear. Not only were they not crushed in the least, but 90 per cent. or more of the stylolites have no fossil on either the top or the bottom, while there are shells in abundance both above and below the stylolite seam, with no stylolites near them.

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* The explanation given above was worked out by the writer in the field independent of the work of the German writers, with which he was not then familiar, going into the field with no theory but the one given by Marsh, as taught by Dana and Geikie, which was soon found to be unsatisfactory, and the one above given is purely inductive incident to the extended observations in the field.

Furthermore, sometimes the stylolites show just the opposite of compression by forming or occurring in an open seam.

The amount of waste caused by the stylolite or crow-foot seam is frequently more than the width of the seam plus the length of the stylolite points, especially so where they occur in the buff stone, as the carbonaceous material in the seam prevents oxidation and there is an irregular blue band along the seam extending several inches to a foot or more from the seam into the buff stone, and the seams are not always the right distance apart to get either one or more cuts of standard size without considerable waste.

Textural features.—The Bedford limestone is a granular limestone, a calcareous sandrock, in which both the grains and the cement are carbonate of lime. The greater part of it is properly freestone in character, although that term is commonly limited to the siliceous sandstones.

The texture varies in coarseness in different parts of the area, and generally in different parts of the same bed. The finest-grained varieties appear to be the most in demand in the markets and hence are the most sought after and the most valuable. In all of the oölitic limestone throughout the area the grains are made up of fossils, mostly foraminifera and bryozoa, mingled with which are other forms, some of which were not identified. The foraminifera are mostly intact, showing little or no evidence of wear. The other forms appear more or less imperfect in places, but apparently more from a leaching action than from wear. The finer-grained forms differ from the coarse in having smaller shells. The great mass of the stone is made up of these minute, almost microscopic, shells which are generally pretty uniform in size, but in some localities the larger forms predominate, in others the smaller forms prevail, hence coarser and finer-grained stones occur. In some places, as at Romona and Heltonville, bryozoa are very abundant. In other places gasteropods and brachiopods abound, often of considerable size—half an inch to an inch in diameter, in a few instances two or three inches. The large forms are commonly clustered, forming a large part of the rock where they occur, and not scattered indiscriminately throughout the rock, and as all of the coarsely fossiliferous stone goes into the waste or into a low grade stone, none of it being sold for first-class dimension stone, the separation is readily made, and if the bed proves to be wholly or largely of coarse stone it is not worked at all. Hence, from a commercial standpoint, the absence of large fossils is desirable.

The fossils, which are composed of finely crystallized calcite, are imbedded in a cement of calcite. On the relative amount, purity and coarseness of this cement depends the hardness and compactness of the stone. To the happy combination of soft grains in the firm cement in the right proportions depends the value of the oölitic stone for building purposes. With any considerable decrease in the amount of the cement the stone would be too soft, crumbling and disintegrating too readily, as is the case in several localities. With an increase in the proportion of the cement the stone would become more difficult to work, losing its freestone character and becoming plucky. There are slight variations in the relative hardness of the stone in different localities, but only in a few places is it too soft to be of any value, and in no place is it too hard to work.

Colors of the Bedford Oölitic limestone.—All the stone of the region is classed as "blue," "buff" or "mixed." The blue is evidently the original color of at least the greater part of the stone, and is thought to be caused by iron in the protoxide form and organic matter, the buff being largely, if not entirely, derived from the blue by oxidation of the iron to the peroxide, and of the organic matter to some volatile form, or some stable form, in which it unites with mineral matter in colorless stable form. The oxidation is a continuous process, not yet complete, carried on mainly by the oxygen in solution in the meteoric water, the circulation of which is accelerated or retarded by a variety of causes, and hence does not take place along parallel or regular lines, so that there is always considerable stone along the contact of the two colors that can not be obtained in suitable dimensions of either color alone, but contains a combination of the two colors, and is classed as mixed stone. In most of the quarries it goes into the dump pile as waste. Occasionally some of it is sold for bridges or foundations at a greatly reduced price, often less than the cost of quarrying it. The price of the good stone is so low, and the freight rates so high, that none but first-class stone is shipped to any considerable distance.

Some analyses, made with a view of determining the cause of this coloration, gave the following result:

*Partial Analyses of Blue and Buff Oölitic Limestone.**

COLOR.	QUARRY.	Inorganic insoluble matter. Per Cent.	Organic. Per Cent.	Ferrous oxide. FeO. Per Cent.	Ferric oxide, Fe_2O_3. Per Cent.
Blue	Thornton's.....	2.16	0.24	0.067	0.196
Buff.....	Thornton's	.86	.12	.050	.126
Blue.....	Hunter's	1.25	.22	.063	.044
Buff.....	Hunter's	1.10	.11	.055	.150
Blue. ...	Perry's........	1.14	.21	.055	.089
Buff.....	Perry's........	1.24	.13	.050	.119

The results are not as satisfactory as might be desired. The samples were taken from three different quarries, in each case from each side of the line of contact at the same place in the quarry, hoping thus to get specimens as nearly identical as possible in everything but color. Each sample was then tested for ferrous and ferric iron and organic matter. The organic matter was determined by drying the residue insoluble in boiling dilute hydrochloric acid at 135° to 140° C. and determining the loss of weight on ignition. While the results are only approximate, they ought to be relatively correct. The percentages are so small that it is doubtful whether the differences are due to more than the possible errors incident to manipulation. Yet it is probably more than a coincidence that the organic material in each case is only half as much in the buff as in the blue. It indicates a loss of organic material, as might be expected. It is more marked than the difference in the iron which is indicated only in the second or third decimal place. There is in each instance a slight decrease in the percentage of the ferrous iron in the buff from that in the blue, and in two examples out of the three an increase in the proportion of the peroxide, which is what was expected. Yet the differences are so slight that, considering the possible errors in manipulation, we do not feel like emphasizing the import of them without further evidence.

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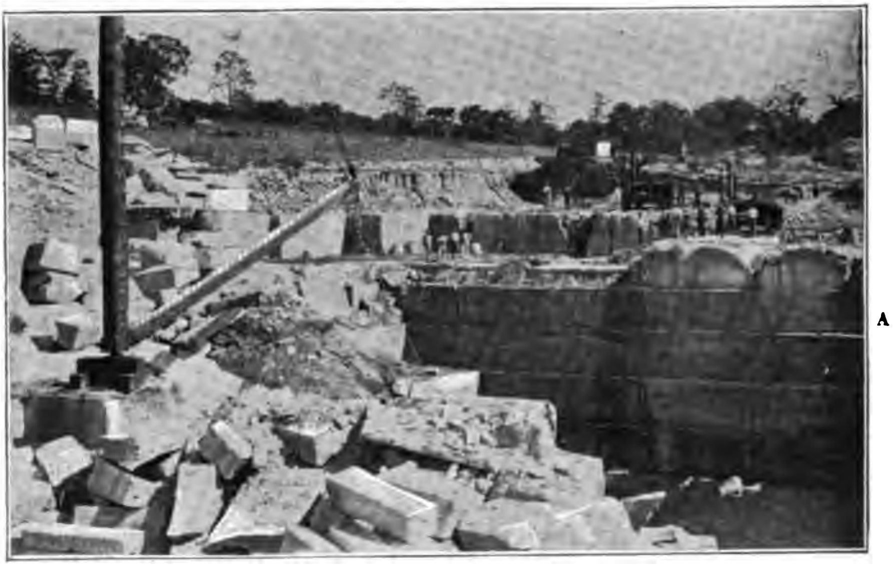
*Made for the Survey by W. A. Noyes, Rose Polytechnic, Terre Haute, Ind.

It should be borne in mind that the difference in color is not great, sometimes scarcely perceptible in a hand specimen, but quite distinct on a large block or quarry face, and is brought out more distinctly by exposure than on a perfectly fresh surface. Thus on the channeled face that has been exposed for a few years the contrast between the buff and the blue is much stronger than it is on a fresh fracture beneath the surface.

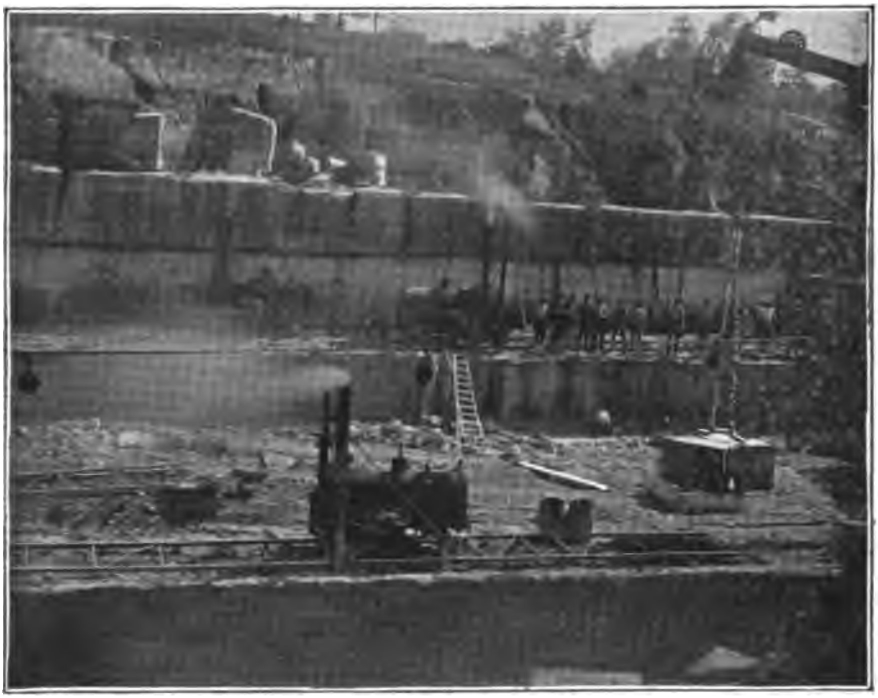
The percentage of bituminous matter is sufficient, in some instances, to discolor the stone to some extent on exposure by the heat of the sun drawing this material to the surface, where it collects the dust and disfigures the stone for a time. Objection has been raised to the stone in some places on this account, but it must be remembered that this occurs with but a small part of the stone, and with that part the disfiguring is only temporary, and in nowise affects the durability of the stone, acting rather as a preservative.

With the exception of the bituminous varieties, the general tendency of the stone is to become lighter colored on exposure. Much of the buff stone has a dull yellow color when first quarried, that becomes much lighter on exposure.

A few years ago the blue stone was the highest priced and most sought after. Now, while there is good demand for both colors, the buff is most sought after and most quarried. The prices are about the same for each.



1. Showing depth of oxidation and line of parting (A) between the buff and the blue stone in old quarry looking north of east.



2. In new quarry, looking south of east, showing method of quarrying, thickness of covering and regularity of the upper surface.

VIEWS IN THE QUARRIES OF THE OOLITIC STONE CO. OF INDIANA, SANDERS, IND.

PHYSICAL TESTS.

Physical tests of various kinds have been tried on the oölitic stone, the results of which are given below. Not only those made directly for the present report, but those made elsewhere, so far as could be obtained, are brought together and classified.

Specific gravity. The specific gravity tests on the accompanying tables were made for the present survey at Rose Polytechnic Institute, except those marked (1), which were made in duplicate at State College, Pennsylvania, to show the different results by different methods. At Rose Polytechnic Institute the stone was weighed in air, and as quickly as possible in water, the specific gravity being the weight in air divided by the difference in weight of the two. At State College it was determined by a specific gravity bottle, weighing first the bottle, second, the bottle filled with water, third, the bottle with the powdered rock, and fourth, the bottle with the powdered rock filled with water. The weight of 3 subtracted from 4, and that result from 2, gives the weight of the water displaced by the stone, and that divided into the weight of the stone, obtained by subtracting 1 from 3, equals the specific gravity. The latter method attempts to give the specific gravity of the particles of the stone independent of the interstitial air, and the former process to give the relative weight of the stone as it is, including the air. As it is impossible to weigh so quickly that some of the water is not absorbed, the actual weight of the stone is less than that shown by the first process. As it is impossible to exhaust all the inclosed air, the absolute weight of the material of the stone, excluding the pores, is a little more than that shown by the second process.

The figures given are for seasoned stone, the green stone being heavier.

The weight per cubic foot, as given in the table, is obtained by multiplying the specific gravity by 62½, the weight in pounds of a cubic foot of water. The quarrymen generally count the weight of the stone in the rough for shipping purposes at from 175 to 180 pounds per cubic foot. C. S. Norton counts his blue stone at 185 pounds. A large block of stone quarried by the Bedford, Ind., Stone Company, said to be the largest block of Indiana limestone ever quarried,* gives the dimensions 11 feet nine inches by 10 feet four inches by eight feet eight inches, and is marked 190,000 pounds (see plate XXXIV), which is equivalent to 180 pounds per foot.

Ratio of absorption.—In the absorption tests made at the Rose Polytechnic Institute the specimens were approximately one-inch cubes, weighed and placed in water, where they were left for 24 hours, and then removed and the faces dried with blotting paper and reweighed. The ratio of absoption is the weight wet minus the weight dry divided by the weight dry. This 1-31 means that 31 pounds of the stone would absorb one pound of water, about five pounds to the cubic foot.

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*There are a great many larger blocks than this quarried now, but possibly no larger ones shipped.

In the recorded tests made by General Gilmore the experiments were made in about the same way.

The stone showing the highest absorption is the most porous, the lightest the softest, and generally, other things being equal, the least able to withstand the weather.

Compression tests.—The compression tests made for the survey at Rose Polytechnic Institute were upon specimens of about two-inch cubes. Each specimen was measured to the nearest 1-100 of a square inch and tested upon a Riehlé testing machine having a capacity of 100,000 pounds.

The specimens were tested between two pieces of tarboard 2¼ x 2¼ inches. The rate of application of the load was slow and the same for all.

It will be noticed that most all of the specimens range between 4,000 and 10,000.

The first two tables show the details of the tests made by Professor Howe at Rose Polytechnic Institute.

Table III gives a summary of these, along with tests made by General Gilmore for comparison. It is worthy of note that in four sets of samples the strength on edge is greater than that on the bed, in one instance the first being twice as great. The reason for this is not apparent. One might think that it was due to an imperfect specimen, but the tests on the bed were made on three specimens which averaged nearly the same, and two of them broke with two perfect pyramids. A possible explanation is that the stonecutter marked them wrong.

The samples from Ellettsville are from G. K. Perry's quarry, a half mile north of the Ellettsville Station.

The Twin Creek specimens from a newly opened quarry on the bluff of Twin Creek, about six miles north of west from Salem in Washington County, Nos. 7 to 9, were specimens quarried in November, 1895, about six feet below the surface, in township 8 north, range 1 west, section 20, on land of John B. Crafton.

Nos. 10 to 12, from second and third floors seven to 20 feet deep in the quarry of Hunter Valley Stone Co., Hunter Valley.

Nos. 25 to 27, quarried Nov. 7, 1896, near the top of ledge, township 7 north, range 2 west, section 24, lot 8. No quarry opened.

Nos. 31 to 33, from quarries on Big Creek, North Bedford station, on Gosport branch of I. & V. R. R., part 20 feet and part 30 feet below the surface; quarried Nov. 26, 1896, hence not properly seasoned.

Nos. 34 to 36, broken off near the top of the ledge, Nov. 7, 1896, on lot 15, township 7 north, range 2 west, section 12. Buff and Blue Oölitic Stone Co. Quarries not developed.

I. *Compression tests on Bedford Oölitic limestone. Specimens on natural bed.*

Number.	COMPANY.	LOCALITY.	Area in Square Inches.	Strength in Pounds Per Square Inch.	REMARKS.
1	G. K. Perry.	Ellettsville.	4.35	6,700	Faces crowned; top pyramid long.
2	G. K. Perry.	Ellettsville.	4.22	5,900	Failed on two sides; signs of pyramids.
3	G. K. Perry.	Ellettsville.	4.33	6,900	Two perfect pyramids.
4	Twin Creek Oölitic Stone & Land Co	Salem	4.08	11,700	Two perfect pyramids.
5	Twin Creek Oölitic Stone & Land Co	Salem	3.92	6,900	One side split off.
6	Twin Creek Oölitic Stone & Land Co	Salem	4.24	11,100	Two pyramids.
*7	John B. Crafton	Bloomington	3.82	11,400	Two good pyramids.
*8	John B. Crafton	Bloomington	3.72	9,100	Two poor pyramids.
*9	John B. Crafton	Bloomington	4.08	8,400	Split off on side; probably tested on edge.
10	Hunter Valley Stone Co.	Bloomington	4.00	3,400	Two fairly good pyramids.
11	Hunter Valley Stone Co.	Bloomington	4.20	4,200	Split off on one side.
12	Hunter Valley Stone Co.	Bloomington	4.08	4,600	Failed on three sides.
13	Romona Oölitic Stone Co	Romona	4.20	6,800	Two good pyramids.
14	Romona Oölitic Stone Co	Romona	4.24	6,400	Two good pyramids.
15	Romona Oölitic Stone Co	Romona	4.20	7,800	Top pyramid good; bottom one-sided.
16	Bedford, Indiana, Stone Co.	Bedford	4.28	6,800	Two fair pyramids.
17	Bedford, Indiana, Stone Co.	Bedford	4.00	3,400	Faces not parallel; failed on one side only.
18	Bedford, Indiana, Stone Co.	Bedford	4.04	6,700	Two fair pyramids.
19	Hunter Bros.' Stone Co	Bloomington	4.14	5,900	Two good pyramids.
20	Hunter Bros.' Stone Co	Bloomington	4.00	6,900	Two good pyramids.
21	Hunter Bros.' Stone Co	Bloomington	4.08	4,400	One side split off.
22	Chicago Bedford Stone Co.	Bedford	4.04	9,600	Two fine pyramids.
23	Chicago Bedford Stone Co.	Bedford	4.12	6,400	Failed on one side; indications that specimen was tested on edge.
24	Chicago Bedford Stone Co.	Bedford	4.12	9,700	Two fair pyramids.
25	John B. Crafton	Bloomington	4.49	6,400	Two poor pyramids.
26	John B. Crafton	Bloomington	4.41	4,700	Split top to bottom around vertical axis of specimen.
27	John B. Crafton	Bloomington	4.54	8,200	Two good pyramids.
28	Crescent Stone Co	Bloomington	4.10	4,500	One poor pyramid and wedges.
29	Crescent Stone Co	Bloomington	4.16	7,500	Two fine pyramids.
30	Crescent Stone Co	Bloomington	4.20	5,000	Two fair pyramids.
*31	Indiana Steam Stone Works	Stinesville.	4.08	6,600	Two fair pyramids.
*32	Indiana Steam Stone Works	Stinesville.	4.16	4,100	Faces not parallel; failed vertically around axis of specimen.
*33	Indiana Steam Stone Works	Stinesville.	4.08	6,200	Faces not parallel; failed vertically around axis of specimen.
34	Bluff and Blue Stone Co.	Bloomington	3.79	6,100	Two very poor pyramids; faces not parallel.
35	Bluff and Blue Stone Co.	Bloomington	4.33	5,800	Top pyramid good; faces not parallel; bottom pyramid wedge-shaped.
36	Bluff and Blue Stone Co.	Bloomington	4.28	6,200	Two good pyramids.
37	Bedford Quarries Co.	Bedford	4.00	3,300	Top pyramid fair; bottom one very poor.
38	Bedford Quarries Co.	Bedford	4.00	4,300	Two fair pyramids.
39	Bedford Quarries Co.	Bedford	4.12	4,800	Failed on two sides; signs of pyramids.

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* The natural "bed" of these specimens was not marked.

II. *Compression tests on Bedford Oölitic limestone specimens on edge.*

Number.	COMPANY.	LOCALITY.	Area in Square Inches.	Strength in Pounds per Square Inch.	REMARKS.
1	G. K. Perry	Ellettsville	4.08	13,500	Failed in two pyramids.
2	Twin Creek Oölitic Stone & Land Co	Salem	4.02	8,900	Failed in two pyramids.
3	Jno. B. Crafton	Bloomington	3.94	8,000	Faces crowning badly out; failed like specimen tested on natural bed.
4	Hunter Valley Stone Co	Bloomington	3.98	4,200	Split off on sides; for most part parallel to the natural bed.
5	Romona Oölitic Stone Co	Romona	4.20	11,200	Failed in two pyramids; fine specimen.
6	Bedford Ind. Stone Co	Bedford	4.18	4,600	Faces not parallel; one side split off. Signs of pyramids.
7	Hunter Bros. Stone Co	Bloomington	4.12	4,200	Failed in two pyramids like specimens tested on natural bed.
8	Chicago Bedford Stone Co	Bedford	4.02	6,600	Faces badly out of parallel; split off on high sides.
9	Jno. B. Crafton	Bloomington	4.45	3,900	Faces not parallel; split off on one side and corner.
10	Crescent Stone Co	Bloomington	4.01	5,700	Faces not quite parallel; split off on one side.
11	Indiana Steam Stone Works	Stinesville	4.12	2,800	Faces not parallel; one face showed tool marks; split off on one side.
12	Buff and Blue Stone Co	Bloomington	4.10	4,100	Split off on one side.
13	Bedford Quarries Co	Bedford	4.12	4,800	Two fair pyramids.

III. *Table showing crushing strength, specific gravity and ratio of absorption of Indiana Oölitic limestone.*

Number.	Quarry.	Location.	Crushing strength per square inch.	No. of specimens tested.	Specific gravity.	Weight per cubic foot.	Ratio of absorption.	Where tested or authority.
1	G. K. Perry	Ellettsville, Ind	6,500 13,500	3 1	. . .	. . . .	1-31	Rose Polytechnic Institute, Terre Haute, 1896.
2	G. K. Perry	Ellettsville, Ind.	12,625	.	. . .	152.4	1-41	Gen. Gilmore, Rep. No. 6, Board State House Commissioners, 1879.
3	Matthews Bros	Ellettsville, Ind.	13,500	.	. . .	142.2	1-28	Gen Gilmore, Rep. No. 6, Board State House Commissioners, 1879.
4	Indiana Steam Stone Works	Stinesville, Ind	5,600 2,900	3 1	. . .	. . .	1-17	Rose Polytechnic Institute.
5	Simpson & Archer	4 miles east of Spencer, Ind	7,560		. .	142 2	1-30	Gen. Gilmore, Rep. No. 6, Board State House Commissioners.
6	Simpson & Archer	4 miles east of Spencer, Ind	8,750	.	. . .	156.9	1-95	Gen. Gilmore, Rep No. 6, Board State House Commissioners.
7	Hunter Valley Stone Co.	Bloomington, Ind.	4,100 4,200	3 1	. . .	. .	1-14	Rose Polytechnic Institute, 1896.
8	Hunter Bros. Stone Co	Bloomington, Ind.	5,700 4,200	3 1	2.46	153 7	1-19	Rose Polytechnic Institute, 1896.
9	Crescent Stone Co	Bloomington, Ind.	5,700 5,700	3 1	. . .	. . . .	1-15	Rose Polytechnic Institute, 1896.
10	Buff and Blue Stone Co.	Bloomington, Ind.	6,000 4,100	3 1		. . .	1-22	Rose Polytechnic Institute, 1896.
11	Crafton	Bloomington, Ind.	6,200 3,900	3 1	. .	. . .	1-16	Rose Polytechnic Institute, 1896.
12	Crafton	Bloomington, Ind.	9,600 8,000	3 1	. .	.	1-3300	Rose Polytechnic Institute, 1886.
13	Dunn & Co	Bloomington, Ind.	13,750		.	146.6	1-13	Gen. Gillmore.
14	Romona Oölitic Stone Co	Romona, Ind	7,000 11,200	3 1	2.48	155.0	1-39	Rose Polytechnic Institute.
15	Bedford, Indiana, Stone Co.	Bedford, Ind.	5,600 4 600	3 1	2.47	154.4	1-23	Rose Polytechnic Institute.
16	The Chicago & Bedford Stone Co	Bedford, Ind	8,600 6,600	3 1	. . .	. . .	1 31	Rose Polytechnic Institute.
17	Bedford Quarries Co	Bedford, Ind	4,100 4,800	3 1	. . .	. . .	1-15	Rose Polytechnic Institute.
18	Bedford Quarries Co	Bedford, Ind	14,000	. . .	. . .		. .	Bedford Quarries Co. Circular.
19	Chicago and Bedford Co	Bedford, Ind	11,750	. . .	.	147.6	1-28	Gen. Gilmore, Indiana Geological Report, 1878.
20	Dark Hollow Stone Co	Bedford, Ind	6,625	. .	. . .	142.9	1-19	Gen. Gilmore, Rep. No 6, State House Com.
21	Dunn & Co	Bedford, Ind	6,500	. . .		147.0	1-24	Gen. Gilmore, Rep. No. 6, State House Com.
22	Twin Creek Stone Co	Salem, Ind	9,900 8,900	3 1	2.51	156.9	1-31	Rose Polytechnic Institute.
23	E. Zink & Son	Salem, Ind	8,625	.	.	144.3	1-22	Gen. Gilmore, Rep. No. 6, State House Com.
24	S. M. Stockslager	Corydon, Ind	10,250	. . .	. . .	149.6	1-27	Gen. Gilmore, Rep. No. 6, State House Com.
25	. . . . .	Bowling Green, Ky	3,000	. . .	.		. . . .	Min. Res. U. S. 1889-90, p. 396.

One is liable to error in making comparison of the crushing strength of building stones made by different persons, or even by the same person, as the maximum strength of the stone depends upon a number of conditions: 1. On the size of the specimen; a large specimen will give a higher result per square inch than a small one. 2. The shape of the specimen, as shown below. 3. The rate of speed of the machine. 4. The accuracy with which the specimen has been dressed; the more nearly absolutely parallel the higher the results. 5. The method of dressing the specimen. The tests showing difference in transverse strength of tool-dressed and sawed samples made by Mr. Johnson apply as well to crushing tests, as shown experimentally by Gilmore. 6. The seasoning of the specimen. 7. The method of bedding the specimen. 8. The care of the operator in watching all the details of the test; and 9. The accuracy of the machinery. The machines are not all calibrated alike. The above points are not all theoretical, but largely based on experience. Hence comparisons on the basis of crushing strength alone should be made with caution.

The following results by Mr. Hatt will illustrate several of the above points:

The relative crushing strength of Bedford limestone in prisms and cubes.[*]—From an examination of the results of J. Bauschinger's investigation of the effect which the shape of a specimen of stone has on its crushing strength, a writer in the "Digest of Physical Tests" for July, 1896, has stated that the strength of a stone prism, whose height is one and one-half times its least lateral dimension, is only 92% that of a cube of the same material. If the normal shearing angle for stone is 60°, this conclusion seems reasonable.

There are here communicated tests on a number of specimens of Bedford oölitic limestone, sawn to cubes (4″ x 4″ x 4″) and the prisms (4″ x 4″ x 6″). They were tested partly directly after being taken from the paper wrappers and rubbed down by hand with emery to a smooth bed, and partly after having been exposed to the air of the laboratory for one month. Part of the series was tested when bedded in a thin layer of plaster of Paris, and part tested directly in contact with the beds of the machine, which was a Riehlé machine of 300,000 pounds' capacity, run at a speed of one-tenth inch per minute. It is to be noted that the specimens were not well seasoned, and so the results are not given as evidencing the full strength of the stone.

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[*] Presented to the Indiana Academy of Science, December, 1896, by W. K. Hatt.

The average crushing strength of the 17 cubic specimens was	4326.7
The average crushing strength of the 14 prisms was	4436.4
Omitting 3 cubical specimens, the strength of the remaining 14 is	4191
Omitting 3 of the prisms, the strength of the remaining 11 is	4305
For those tested with plaster bed the average is	4239
For those tested without plaster bed the average is	4359
For those tested December 17th the average is	4385
For those tested before November 18th the average is	4274
The average of all specimens is	4381.5
The average with six omissions is	4248

In these tests of 31 specimens the six-inch prisms had, under all conditions, a greater strength than the cubes of the same sectional area, and the difference does not amount to three per cent.

The average angle of pyramid of fracture is 64.5 degrees. The results do not sustain the conclusion mentioned above as having been stated in "Digest of Physical Tests."

Fire tests.—There seemed to be some doubt in regard to the heat-enduring properties of the oölitic limestone, and a series of tests were made for the survey at Rose Polytechnic Institute, with the following results: A sufficient number of specimens from different localities were taken, we think, to fairly represent the whole district. The results appear to be about the same in each test, so that it is not necessary to enumerate the different localities under each test.

It will be seen that the results are all that could possibly be desired or expected, since the samples retained their form uninjured up to and beyond the point of calcination.

The specimens were approximately one-inch cubes, all supported in the same manner on wires placed ¾ inch apart, and all heated under similar conditions in a furnace composed of an iron box surrounded by an iron jacket, leaving a two-inch space on all sides but the front and bottom.

Specimens were taken from the following quarries: G. K. Perry's, Ellettsville; Hunter Valley Stone Co. and Crescent Co., Hunter Valley, Bloomington; Romona Oölitic Stone Co.'s Quarry, Romona; The Chicago and Bedford Stone Co., Reed's Station; The Bedford Indiana Stone Co., Peerless; The Bedford Quarries Co., in the vicinity of Bedford; The Twin Creek Co., Twin Creek, northwest of Salem; The Buff and Blue Oölitic Stone Co , and two localities on the property of the Crafton Stone Co., south of Bloomington, and the quarry of the Indiana Steam Stone Works, on Big Creek, West of Stinesville.

The specimens were first heated until lead melted on their top surface, about 619° F., and cooled slowly in air—all specimens uninjured. Other specimens heated to the same temperature were sprinkled with water and then quenched in cold water—all uninjured.

The same experiment was tried with melting zinc, temperature about 777° F., with the same result—specimens all uninjured.

The specimens were heated until cupric chloride ($CuCl._2$) melted, temperature about 928° F., and some were cooled in air and some sprinkled and quenched in water. The specimens retained their form and were uninjured except a discoloration very slight in some and pronounced in others, due to the oxidation of the iron. Three specimens showed indications of lamination.

They were then heated until aluminum melted on the upper surface, temperature about 1157° F. They were sprinkled and quenched in water. The lower edges crumbled when sprinkled. The upper edges and faces were uninjured.

Some were heated to "cherry red," about 1500° F., and cooled in air, calcination was pronounced, but the specimens retained their cubical form and sharp edges.

Other specimens were heated to the temperature of melting potassium chloride, KCl, sprinkled and quenched in water. The lower edges went into fine powder (quicklime). The upper edges were uninjured.

These results show pretty conclusively that the oölitic stone is fire-proof up to the point of calcination or turning to quicklime, in which respect it is superior to the average building stone, so far as shown by the published tests. While a few building stones will withstand a temperature above the calcination point of lime uninjured, the greater number will be destroyed at a temperature below that point.

Transverse strength and elasticity.—Mr. Johnson made a series of tests on the transverse strength and elasticity of the oölitic limestone, a few of the results of which are given below,[*] as the original source is not accessible to all.

He tested specimens having approximately one inch cross-section and 14 inches long, by resting them on supports at the ends and applying the load to them on a knife edge in the center. They were all measured accurately in cross-section, most of them varying from a square inch by a small fraction.

AVERAGE RESULTS FROM EXPERIMENTS ON SAWED AND TOOL-DRESSED SAMPLES OF OÖLITIC LIMESTONE.

	Load causing rupture, in pounds.	MODULUS OF		
		Rupture.	Compression.	Elasticity.
Sawed	130	2,338	12,675	4,889,480
Tool-dressed	81	1,477	7,857	2,679,475
Ratio of tool-dressed to sawed	62 per cent.	63 per cent.	62 per cent.	55 per cent.

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[*] **Experiments upon the Strength and Elasticity of Building Stones, by Thos. H. Johnson, in the 11th Ann. Rep. Dept. Geol. and Nat. Hist. of Ind., 1881, pp. 34–42.**

For the tool dressed specimens the breaking loads varied between 40 and 110 pounds; for the sawed specimens, from 120 to 150. The modulus of rupture for the tool-dressed specimens varied between 950 and 1,928; for the sawed specimens between 2,187 and 2,593. These results show quite conclusively not only the great elasticity of the stone, but the injurious effects of hammering it in tool-dressing. Mr. Johnson also noted that the strongest stones were the most resonant. All the tool-dressed specimens had a dull sound, while the sawed specimens had a clear, ringing sound. It should be noted that the sawed specimens were taken from different quarries from the tool-dressed ones and part of the difference in the results may be due to inherent qualities in the stone.

Chemical composition.—The accompanying table gives a record of all the analyses obtainable of the oölitic limestone from different localities. The similarity is remarkable. Thus the percentage of carbonate of lime varies between 95 per cent. and 98.27 per cent., a variation of but little more than three per cent. in 16 different samples from widely separated localities, varying from Romona on the north to near the Ohio river on the south.

The percentage of magnesium carbonate is less than one per cent. in all the specimens except two from Big Creek, and there is a possibility in that case that the greater quantity may be due to error in analysis.

The insoluble residue which includes the silica, insoluble silicates, and organic matter, averages less than one per cent., never as high as two per cent., and only four running over one per cent.

The iron and alumina combined average less than one per cent. The alkalies form a mere trifle.

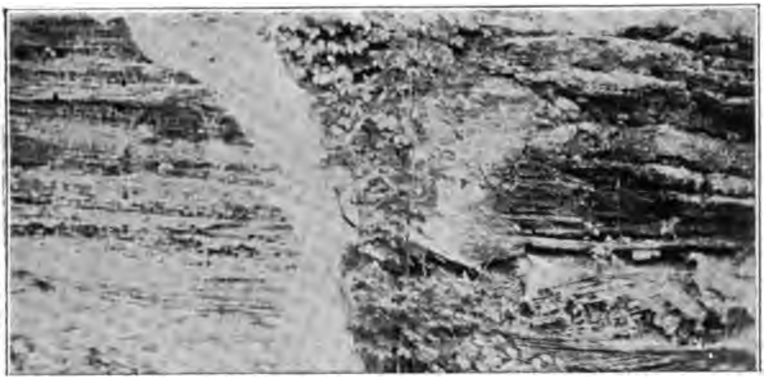
The last column, headed water, in the two analyses, where it shows more than half of one per cent., includes water and loss on ignition. Probably the greater part in each is due to the unavoidable errors of analysis.

The analyses show the stone to be a lime carbonate of remarkable uniformity and purity. Possibly no other stone in the country would show such a remarkable uniformity of composition over such a wide area.

Thus, from the standpoint of purity, the stone is all that could be desired, only the purest marbles giving a higher percentage of lime carbonate.

Chemical Analyses of Bedford Oölitic Limestone.

Number.	LOCALITY.	QUARRY.	Date.	Lime carbonate, $CaCO_3$.	Magnesia carbonate, $MgCO_3$.	Insoluble.	Iron oxide, Fe_2O_3.	Alumina, Al_2O_3.	Alkalies, K_2O, Na_2O.	Water, H_2O.	Total.	AUTHORITY.
1	Bedford	Bedford, Indiana Stone Co.	1896	98.27	.84	.64	.15	...	...	...	99.90	W. A. Noyes, Rose Polytechnic Inst.
2	Hunter Valley	Hunter Bro.'s quarry	1896	98.11	.92	.86	.16	...	...	...	100.05	W. A. Noyes, Rose Polytechnic Inst.
3	Romona	Romona Oölitic Stone Co	1896	97.90	.65	1.26	.18	...	...	...	99.99	W. A. Noyes, Rose Polytechnic Inst.
4	Twin Creek	Twin Creek Stone & Land Co	1896	98.16	.97	.76	.15	...	...		100.04	W. A. Noyes, Rose Polytechnic Inst.
5	Big Creek	Indiana Steam Stone Works	...	93.80	4.01	.15	.64	...	...	1.09	100.00	L. H. Streaker, State University.
6	Big Creek	Indiana Steam Stone Works	...	93.07	4.22	.50	.71	...		1.19	100.00	L. H. Streaker, State University.
7	Bedford	Chicago and Bed. Stone Co.	1878	96.60	.27	.50	.98	...	.40	.61	100.00	Indiana Geological Rep., 1878, p. 95.
8	Bedford	Hoosier Quarry, buff.	...	98.20	.39	.63	.39	...	...	...	99.61	Bedford Quarries' Co. Circular.
9	Bedford	Hoosier Quarry, blue		97.26	.37	1.69	.49	...			99.81	Bedford Quarries' Co. Circular.
10	Four miles E. of Spencer	Simpson & Archer	1878	96.79	.23	.70	.91	...	.32	.41	99.90	Indiana Geological Rep., 1878, p. 91.
11	Bloomington	Dunn & Dunn Qua'y, white	1881	95.62	.89	1.74	.23	.06	...	.59	99.45	Indiana Geological Rep., 1881, p. 32.
12	Bloomington	Dunn & Dunn Quarry, blue	1881	95.55	.93	1.60	.09	.09		.42	99.37	
13	Bloomington	Dunn & Co.	1878	95.54	.40	.65	1.00	...	.55	.25		Indiana Geological Rep., 1878, p. 95.
14	Stinesville	Monroe Marble Co.	1862	95.00	.22	.90	3.00		.83	.05	100.00	Ind. Geol. Rep., 1862. Owens, p. 137.
15	Salem	...	1886	96.04	.72	1.13	1.06		.15	.10	...	Indiana Geological Rep., 1886, p. 144.
16	Harrison Co.	Stockslager's quarry	1878	98.09	...	.31	.18	.14	.40	.12	...	Indiana Geological Rep., 1878, p. 96.
	Average	...		96.50	1.00	.88	.75	...	.17	.29	...	
17	Hardin County, Ill.	Rosiclare Oölitic limestone	1882	90.16	3.18	2.72	1.06	...	...	.15	...	Econ. Geol. of Ill., Vol. I, p. 318.
18	Bowling Green, Ky	...	1889	95.31	1.12	1.42	.39	...	...	1.76	100.00	Min. Resources U. S., 1889-90, p. 395.
19	Portland, Eng.	...		95.16	1.20	1.20	.50	...	...	1.94	100.00	Min. Resources U. S., 1889-90, p. 395.



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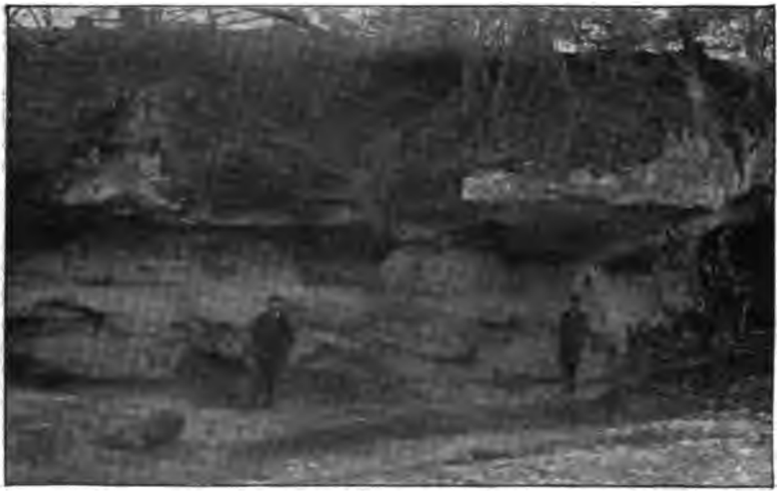

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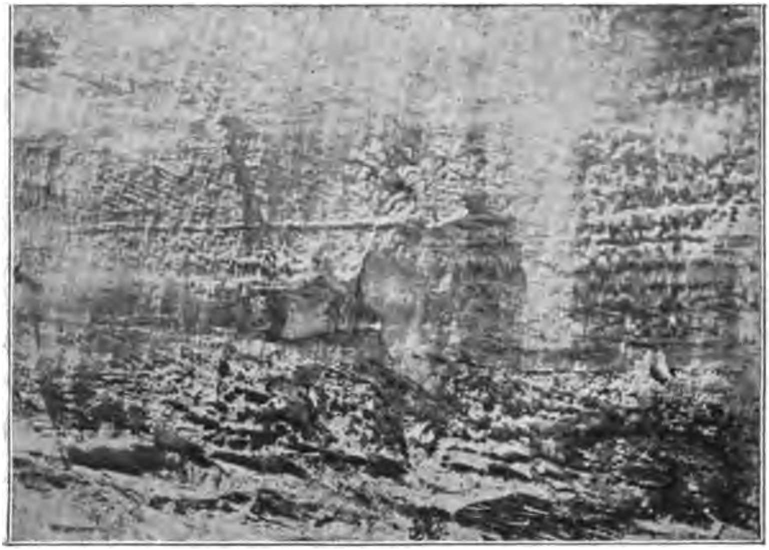

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SHOWING STRUCTURAL FEATURES OF THE OOLITIC LIMESTONE.

1. Bluff on Big Creek showing lamination and cross bedding brought out by weathering.
2 Buff and Blue Oolitic Stone Co., Lot No. 20, N. W. N. W. ¼ Sec. 13, T. 7 N., R. 2 W., showing manner of weathering in oolitic stone along stream courses.
3 Terre Haute quarry. Part of joint face surface, showing gross regularity and minute

Durability of the oölitic limestone.—The Bedford oölitic limestone ranks among the most durable building stones in the market, the proof of its durability being found in (1) the appearance of the stone in the outcrops; (2) in old buildings and monuments; and (3) the chemical and physical tests.

The outcrops of the oölitic limestone are in some places rounded prominences projecting through the soil, in other places bold cliffs along the watercourses. These cliffs sometimes show a large face of stone, remarkably regular and even, denoting a stone of great uniformity. Plates XXX and XXXVI show two of the largest and finest exposures to be found in the entire area. As the weathering agencies attack the rock always at the weakest spots, if there are any, the outcrop is frequently irregular from the deeper weathering along seams, joints or lines of weakness. See the upper weathered surface of the stone in Nos. 1 and 2 on plate XX, and the views in plate XXI. Where the watercourse has its channel in the oölitic limestone, it frequently cuts a deep, narrow gorge in which it runs, and sometimes undercuts the rock on one side, or the other, forming overhanging bluffs. (See plate XX.) The number and the prominence of the bluffs, the most conspicuous topographic features of the region, indicate its greater durability in comparison with the overlying and underlying rocks.

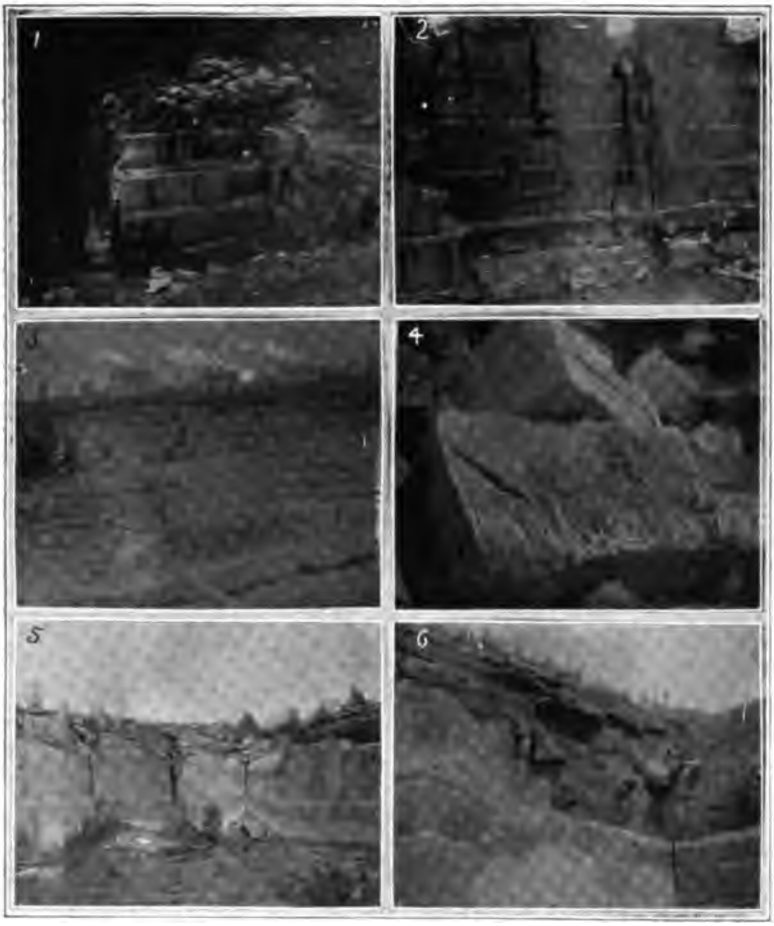
As the oölitic stone field is a comparatively new one in its larger development, there are not many old structures in which the stone has been exposed for a long period, as is the case with stone in the Eastern States. However, such as have been erected are, without exception, so far as known, in a good state of preservation. The Winthrop Foote vault on the east side of Bedford, constructed in 1840, and the stone chimney on the old homestead of Dr. Foote, built before that date, are the oldest pieces of work in the Bedford stone known to the writer. They are apparently as sound as when first erected, more than fifty years ago. Of the many buildings constructed wholly, or in part, since that time, and of the numerous monuments in the cemeteries, none that are injured in any way, except sometimes by discoloration, have been observed. The same can be said in part of the rock in the old quarry openings south and east of Bedford that were made 40 or 50 years ago. The stone in the dump and on the old quarry face is, as a rule, as sound and firm, and harder than when just quarried. Where the stone lies under the trees, or in well shaded places, it is covered by a vegetable growth, like all other building stones in similar positions; and in a few of the more recent quarry openings the stone is shelly and exfoliating for a few feet above the water that stands in the quarry, caused, presumably, by the freezing of the wet stone, but in nearly every instance of this kind it is a band of very coarse texture, of coarsely fossiliferous stone, that is shelly, while the fine-grained stone, both above and below it, remains firm. It is said that some of the ground courses in bridge abutments have been known to scale and exfoliate. None such have been seen by the writer, but his opportunity for observation in this line has not been extensive.

The chemical analyses show no marked percentage of elements of weakness in the stone any less stable than lime carbonate, the percentage of alumina and alkali being too minute to affect the strength in any way. The stone is practically a carbonate of lime, one of the most durable substances under ordinary conditions. In contact with acids, however, it is one of the least stable, as it is readily dissolved by any of the acids. For this reason it is liable to tarnish in a city atmosphere where there is much sulphurous coal smoke. However, unless it is in the immediate vicinity of a large furnace or factory the injury from this cause is little to be dreaded beyond the roughening and sometimes discoloration of the surface.

The numerous fissures, caves, open seams and corrugated surfaces found in the quarries and outcrops are caused by its solubility in acids, as the rainwater absorbs some acid from the air and more from the soil through which it passes, and, acting continuously for ages, it leaches away great quantities of the stone. This action, which is so marked in the stone in its natural position, ceases almost entirely when the stone is placed in the wall, as the circulation of the sap or interstitial water ceases, its load is deposited and many of the pores are closed. The little water that falls on the surface during a rain storm contains but little acid and that under such slight pressure as not to be very active, and of the little that is dissolved by carbonic and sulphuric acids part is redeposited in the pores, tending to make the surface more impervious. It might readily be inferred, then, that it should not be used where it will be exposed to the action of acids. For that reason it is not suitable for the base of bridge-piers in regions where the water is very acidic, as in coal mining regions.

The physical tests show the stone to be more porous than the average limestone, but in crushing and transverse strength up to or beyond the average; much more flexible and elastic than the average building stone, by means of which it is able to withstand sudden changes of heat and cold without injury, that would cause less elastic stones to crack or crumble. This is shown by the heat tests described above, in which the stone remains intact, uninjured, under heat up to the point of calcination, even standing sudden cooling in cold water from a nearly red heat, that is, a sudden change of nearly a thousand degrees, which is probably as severe a test as any to which a stone could be subjected.

This happy combination of properties, by means of which this oölitic stone, while so soft as to be so easily cut and carved into desired shape, is at the same time so firm and elastic as to withstand the strains put upon it either by its position in the structure or the strain of rapid changes in temperature, makes the stone so valuable for building purposes. This is



STRUCTURAL FEATURES OF THE OOLITIC LIMESTONE.

1. Hunter Valley quarry, showing corrugations and *irregularity* of the weathered upper surface after removal of the soil.
2. A Big Creek quarry, showing excessive weathering along the joints.
3. Johnson quarry, showing *regularity* of the upper surface after the removal of the soil.
4. A peculiar porous form of weathering.
5. In Perry's quarry, showing cross bedding.
6. In Perry's quarry, showing line of contact of the oolitic limestone with the overlying Mitchell limestone.

due probably to its unique texture as already stated, in which it differs from other sandstones in having the grains cellular and porous in a fine cement. It differs from other limestones in its granular character, consisting of the yielding grains in the finer cement. And furthermore, calcite itself is highly elastic, as shown in the action of many of our marbles.

The Bedford oölitic limestone can unhesitatingly be recommended as one of the most durable building stones in the market, where not exposed to the action of acids. It is fire-proof up to the point of calcination, in which property it can be surpassed by no other limestone and but few other building stones, as very few are absolutely fire-proof.

We cannot refrain at this point from calling attention to the extravagant, boastful and misleading statements made by some previous writers on this subject, statements that are injurious because false. Such statements as the following, by their very extravagance, defeat their object: "This purity insures absolute integrity on exposure to the fumes of coal, while the perfect elasticity and flexibility of the mass render it invulnerable to the forces of cold and heat, air and moisture. Cliffs of this limestone, exposed to our variable climate for unknown centuries, show no sign of disintegration, the finest angles standing out as sharp now as when first the mass was fractured." And from another writer: "At the numerous exposures along the various watercourses, where it has been subjected to the action of the elements for hundreds and thousands of years, it does *not display* in *a single instance* a *tendency* to *disintegrate* or *break down* under prolonged exposure."

To say nothing about the above statements, one only need to look at the accompanying photographs, or visit any of the outcrops, to see the absurdity of such statements. Again the following awe-inspiring statement has been quoted and requoted with an apparent confidence that seemed to settle all doubts: "When we consider to what awful and prolonged frigidity of temperature this rock was exposed during the Glacial age, without in the least affecting its integrity, we may safely trust it in our buildings. Other limestones were cracked, shivered, crushed under the compressions and expansions of the arctic period, while this massive deposit was scarcely changed in any part of its great body." The "awful and prolonged frigidity" of the Glacial age presumably never reached the main body of the oölitic limestone, at least the glacier itself did not. It stopped near the north end of the oölitic region, probably because of the very opposite condition to frigidity, as the best barrier against ice is heat, and likely the warm climate of this part of Indiana stopped the glacier in the extreme northern part of Monroe County or beyond by melting its southern end. Furthermore, the part of the oölitic belt that the glacier passed over is not the part that contains the best stone, and again the "other limestones" in the glacial areas are no more "cracked, shivered and crushed under the compressions and expansions of the arctic period" than similar stones are many miles south of the glacial area. The truth in regard to the durability of the oölitic stone is sufficient, and needs no embellishing.

Workability.—The Bedford oölitic limestone probably works as easily and freely as any other building stone in the market, almost rivaling the French Cæn limestone in this respect. While the French stone is a little softer and more easily cut, it is said to be much less durable in a northern climate. Like all freestones, the Bedford stone is much softer when first quarried, hardening on exposure; hence it is more easily sawed or cut to the desired form when fresh than it is after seasoning. Yet while it becomes firm and compact, resonant almost as a metallic substance, calcite in itself being a soft mineral, it never becomes as hard or as difficult to cut as siliceous rocks of equal strength; nor does it become as hard as marble. The lack of grit or siliceous material thus renders the channeling of the stone from the quarry, the sawing of the stone and the cutting and carving of it not only possible, but enables it to be so worked much more economically than almost any other building stone, a saving of both time and wear on the tools when compared with sandstones of equal strength, or granite, or even marble or more compact limestone. Beides being easy to channel, cut or saw, it also splits as readily as almost any other rock, where not locally cross-grained, splitting or breaking readily in any direction, excelling the average building stone in this respect, thus adding to its value for ornamental work. These properties enable it to be removed profitably from a massive bed containing few seams, where a harder stone or one more difficult to work could not be quarried with any profit.

Accessibility.—The Bedford oölitic limestone area is near the center of population of the United States, in the very midst of the Mississippi Valley, which is not only the largest, but destined to be the most productive and populous valley of the world. The area is traversed by one north and south railroad, and three running east and west, besides several branch roads. The topographic features are such that almost every point of the area can be reached by railways at a moderate expense for grading. In evidence of the easy grades, the Monon railway, running north and south on the entire length of the productive area, was built before the great value of the stone was known. The structural position of the stone, lying, as it does, with a gentle dip to the southwest, makes a larger area of the stone accessible than if it were inclined at a high angle or even perfectly horizontal.

A stone may be inaccessible because of its remoteness from markets, such as large cities or populous districts, or its distance from railroads or other means of transportation, or because of its structural and stratigraphical position. Thus an intrinsically good building stone in many of the Western States would not be accessible to Eastern markets, even though it were on a railway, because of the excessive freight rates. Throughout North Arkansas are valuable beds of marble, but they are inaccessible, because they are many miles from a railroad. A bed of stone, inclined at an angle of 40 to 60 degrees to the horizon, has but a small part accessible, likewise a bed in a horizontal position, overlain by a very durable rock, is liable to be accessible in very limited areas. The Bedford oölitic limestone as noted, is not subject to any of these difficulties.

CHAPTER III.

COMMERCIAL FEATURES OF THE BEDFORD OÖLITIC LIMESTONE. METHODS OF QUARRYING AND HANDLING THE OÖLITIC LIMESTONE.

T. C. H.

The earliest settlers did not use much of the oölitic limestone, because of the difficulty in quarrying it. After its valuable properties were discovered, it had some local usage, in which the stone was obtained by the liberal use of powder from the loose bowlders and outcropping ledges. It is the almost universal practice among country masons, where the stone is to be quarried by hand, to blast it from the ledges, and if the blocks or bowlders are too large to handle, to break them with another charge of powder. With the invention of the channeling machine and the opening of the large quarries, the use of powder was discontinued, and at the present no powder is used except for removing stripping. The noise of the blast has given way to the clatter of the channeler.

Selecting a site for a quarry.—The primary object desired in all cases is the greatest possible thickness of good stone with the least possible stripping and the least possible amount of waste in the stone quarried. It generally costs as much per yard, sometimes more, to remove the waste stone and stripping as it does the good stone. Hence the less there is of it the less the expense proportionally. The ideal condition where there is no stripping and no waste does not exist in the Indiana limestone belt, nor, in fact, in any other region. The proportion of waste may be less in places, but never wholly absent. Within certain limitations the amount of stripping and the amount of waste in the bed are in inverse proportion to each other. That is, where the stripping is very light, the weathering agencies penetrate deeply along the joint planes, wasting much of the rock, while a thick covering will protect the stone underneath. This relation applies only to the waste due to weathering, and not that due to the stylolite seams or the large fossils, both of which are independent of the weathering or the amount of covering. It applies also to stripping of the same kind of material, as a heavy thickness of soil is not so good a protection from the leaching agents as a much thinner covering of less porous rock that would retard the access of acid-bearing waters. The weathering agencies find ready access through the soil, and the upper surface of the rock is then not only deeply weathered and much corrugated, but the inequalities are all packed full of soil. As a rule, soil covering is more expensive to remove than rock covering.

A ledge in or near the bottom of a valley is more likely to have blue stone than one near the top of the hill. Stone below or close to the drainage level will in most cases be blue, and that above the drainage level will, if not all buff, always have some buff stone, the quantity depending upon the height above the drainage level and the thickness and character of the covering and the texture of the rock itself. The quarries on high ground will then, as a rule, have more buff stone than those on the hillsides or in the bottom of the valley.

The upper surface of the stone is liable to be more corrugated and deeply weathered on a narrow ridge or pointed hill than on a broad flat hill or gentle slope.

Then in selecting an opening, if one desires buff stone in the most favorable locality, let him seek a place where it lies at or near the top of the hill, where at least the greater part of it has a thin rock covering, simply enough to prevent deep corrugation; a heavy rock covering would not only be expensive to remove, but will prevent oxidation and hence have some blue or mixed stone. If the hill is a low one, that is if the valleys are shallow and the slopes gentle, the position is all the more favorable. Many persons seem to think that the desirable condition is to have the stone outcrop at the surface wholly or nearly free from covering, a mistake which many persons have discovered at great loss, after opening a quarry at such a point to find the stone much disintegrated and filled with large, irregular fissures.

A study of all the outcrops in the vicinity and an examination of the nearest quarry openings will often aid greatly in inferring the probable conditions at any locality.

Testing the quarry.—Having made a careful study of the area and selected what appears to be the most desirable location, it is advisable to test the wisdom of the selection in the cheapest manner possible. The points that one wants to know are:

1. The thickness of the bed.
2. How many stylolite (crowfeet) seams.
3. How much blue and how much buff.
4. The texture of the stone, its homeogeneity and coarseness of fossils.
5. How many joint seams and how much the rock has weathered along them.
6. The thickness and character of the overlying material.

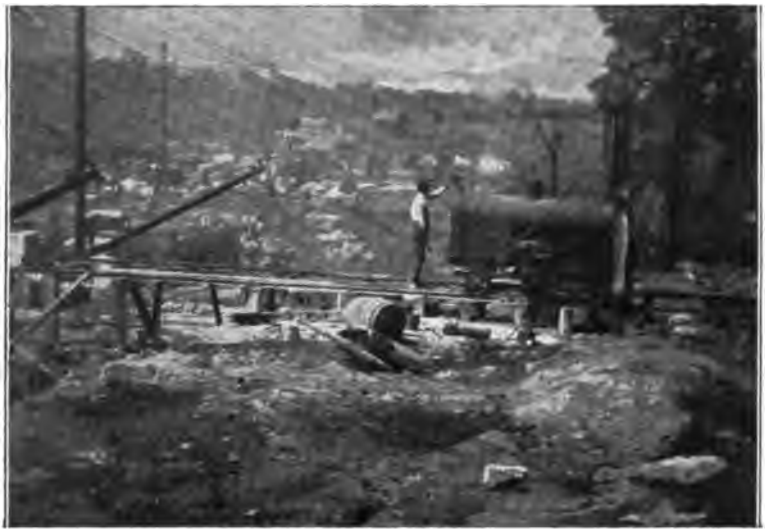
Some of these queries can be answered in part by a careful surface examination by one skilled in geology, but a complete answer requires further investigation which may be done by core drilling, or by channeling. It is not wise to go to a great expense such as stripping or channeling over a large area and putting in expensive machinery until an opening has first been made through the bed, to prove the quality of it, no difference how favorable the surface indications may be.

If the property is in a new locality, the most judicious method would be first to make one or more openings with a core-drill, which may prove the stone worthless from the number of stylolitic (crow-feet) seams, the coarseness of texture or abundance of large fossils, abundance of pyrites or other impurity. If the core shows good stone, the next step would be to channel an opening through the bed. If this shows a sufficient thickness of stone of good quality, with a not too large percentage of waste, a branch railroad may be constructed to the quarry and sufficient machinery put in to run it on the scale desired.

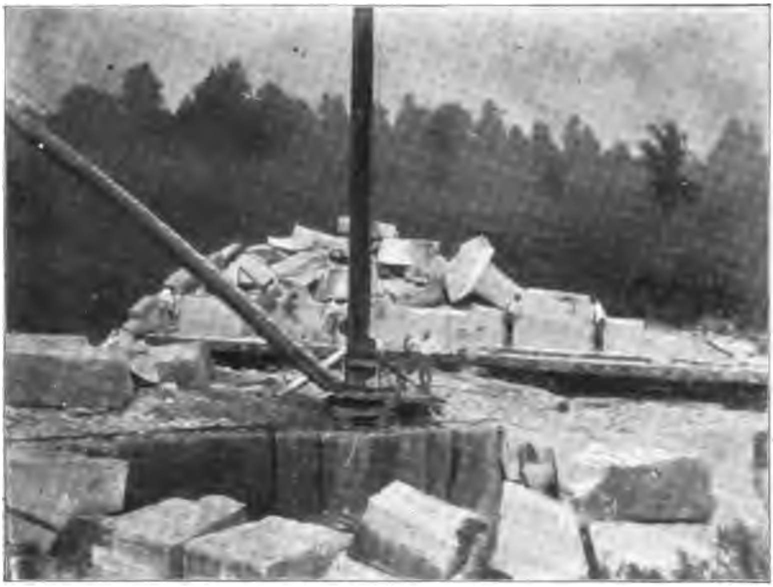
In some instances this procedure has been reversed at a loss to the operators of many thousands of dollars for useless improvements. The preliminary work is of course unnecessary if the quarry is a good one, but experience has demonstrated that a quarry can not be worked profitably at every point in the oölitic limestone, and it is much cheaper to prove the value of a location on a small scale than on a large one.

Method of working the quarry.—Having found an extensive body of good stone and made an opening, it then remains to remove the stone in the most economical manner possible. Practically the same method is employed throughout the district and one description applies to all the quarries with but slight variation of detail. First, channels are cut across the quarry with the channeling machine to a depth varying from six to ten feet, standard sizes being six feet six inches, and ten feet, but the depth may be governed by the size of the blocks desired and sometimes by a seam or change in color. The channels are sometimes cut both ways, that is, two sets at right angles to each other, but frequently if the face is not more than 30 or 40 feet long, the channels are only run in one direction, and a single cut channeled across each end, so that the stone is free on all sides but the bottom. The channels are usually run parallel or at right angles to the open clay seams. The cuts may be at varying distances apart, but are frequently the width of the channeling machine so that two channels may be cut at once. Sometimes the track is moved half its width and another channel cut between, the width depending generally on the sized block wanted to fill the orders. The first block is wedged or broken loose in the best way possible, frequently broken in the process, after the first block is removed the process is simple and rarely any loss. Unless the quarry has one side open, as on the face of a bluff, it is advisable to keep a central opening lower than the main floor so that the dust from the chisels may be washed from channel cuts during the process of channeling by running water.

After the stone is channeled free on all sides, a series of holes a few inches in depth is drilled along the bottom and plugs and feathers or simple wedges are inserted and driven in by the workmen striking them



1. Hoosier quarry. Upper surface of the limestone after removal of the soil, showing also method of channeling on the side hill to get a level floor.



2. Consolidated Stone Co., Quarry No. 1. Scabbling the stone on the car.

CHANNELING AND SCABBLING.

successively until the strain becomes sufficient to crack or split the stone free from the bed. A grappling hook is then attached to the derrick rope and hooked to the top of the loosened block by means of which it is thrown over on its side. If it is a long block, too large to handle, it is then marked off in the size of blocks desired, and along these lines a row of shallow holes is put in with a steam drill, and by driving in wedges the stone is readily split along the desired line. . This is a quicker and cheaper process than the cross-channeling. The block is then lifted by the steam-power derrick and placed on the railway car where, if the stone is to be shipped to distant points before working, it is scabbled (that is, has all the bumps and projections trimmed off with the scabbling tool, a heavy sharp-pointed pick) into regular rectangular blocks, mill blocks (see plate XXII), or else the car is run to the mill and the rough blocks sawed to the desired dimensions.

There is practically very little work done by hand in the quarries that can be done by machinery. The loading of the spalls and waste into the dirt boxes and the scabbling is about all that is done by hand in the quarry. The stripping is sometimes done by hand. If the covering consists of soil or dirt, it is removed as far as possible by dirt or road scrapers, but where the upper surface of the stone is much corrugated or weathered unevenly it can only be removed by hand. The most burdensome work that is done by hand is the scabbling or squaring the blocks. It seems strange that pneumatic power should not be used for this. Pneumatic tools for scabbling and carving are used to considerable extent in some localities, and one would think that they could be used to advantage here where there is so much of the work to be done.

The only place that blasting is used is in removing rock stripping, which is generally done in the winter season. It seems a little strange that the Knox blasting has not been used, as the stone could be removed in that way often with less expense. It is fortunate for the credit of the stone that it has not been used, and it is to be hoped that it will not be.

Machinery used.—The machinery in a fully equipped quarry and mill consists of steam channelers, steam drills, derricks, hoists, steam or electric travelers, saw gangs and appliances, planers, jointers or headers, lathes and, perhaps, a rock crusher, with a cost of many thousand dollars. The *channelers* or channeling machines are small locomotives that carry a gang of steel chisels on one side of the engine—single channeler—or a gang of chisels on each side—double channeler—and move back and forth on a movable track of their own, striking with these chisels as they go, thus deepening the channel at each trip. There are two types of channelers, one in which the chisels are attached to the end of the piston and the force of the steam is transmitted directly to the rock. In the other type, which might be called the gravity machine, the drills are attached to a lever which is raised by an eccentric attachment and the blow is given by the weight of the chisels as they drop on the stone, to be again lifted for another blow. The Ingersoll and Sullivan channelers belong to the first or direct-acting class, the Wardwell and the Bryant to the second class. The Wardwell is the oldest machine, the first one having been constructed by George J. Wardwell in 1863. It is simpler, cheaper and more easily managed than the direct-acting machines, which, combined with the fact that it is older and better known, is probably the reason why more of them are used in this locality than of the direct-acting machine, which cuts faster and closer to the wall than the other, but costs more and is not so simple in operation. The Bryan channeler belongs to the Wardwell type of machines, one of the distinctions being that the chisels are at the rear end in the Bryan and the forward end in the Wardwell.

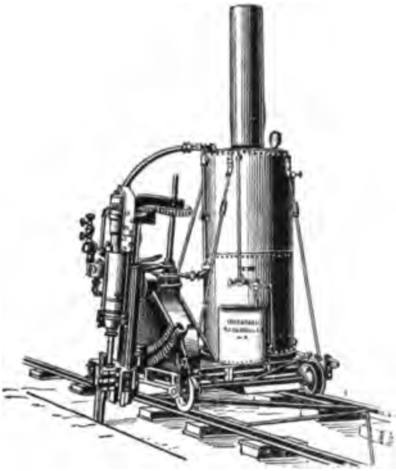


Fig. 5. The direct-acting steam channeler in operation.

The accompanying figure shows the Ingersoll channeler. The Wardwell and others are shown in several of the illustrations. (See plates XXII, XXXII and XXXIII.)

The steam drill most commonly used throughout the area is the Ingersoll "Baby Drill," see Fig. 6. Although electric and compressed air drills are used in considerable numbers elsewhere, so far as known to the writer none are used in the oölitic region. Compressed air is said to be used for driving the drills and for other purposes at the large limestone quarries of the Casparis Stone Company at Kenneth, in the north part of the State; by A. B. Keeport & Co., Logansport, and in some of the cement quarries in the southern part of the State. It is a power that seems to be growing in favor, and we expect to see it soon introduced into the oölitic stone quarries. Hand drilling is rarely resorted to, except in small local quarries.

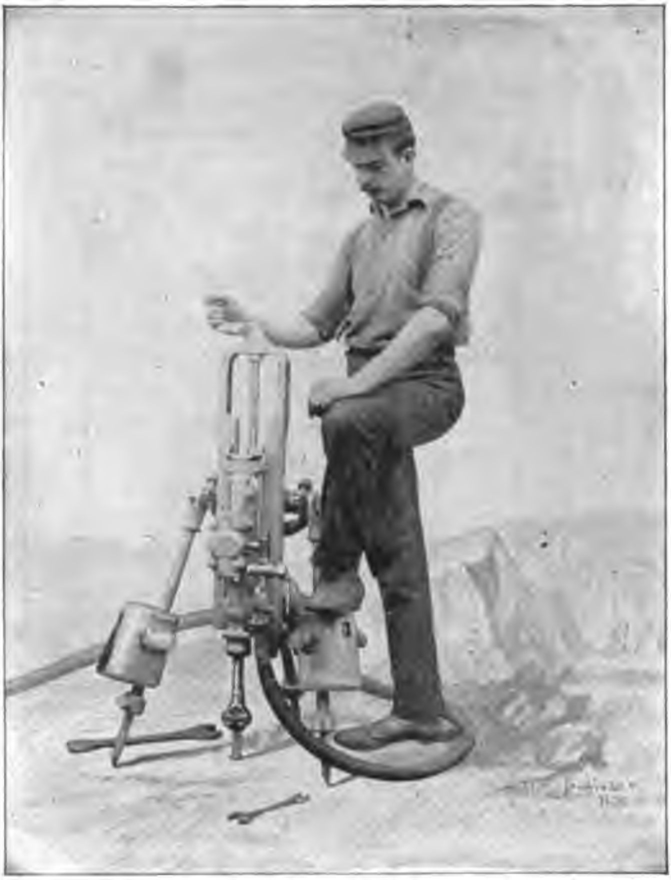


Fig. 6. Steam drill in operation.

Derricks and hoists.—Nearly all the stone is handled by large, heavy capacity, steam-power derricks. The boom-lifting derricks are used almost universally. They are built large and strong, with rarely less than nine guy ropes of galvanized iron cable and 20 to 30 tons capacity. Where properly located they have a reach over a circle 200 feet or more in diameter. Frequently two or three or more derricks are operated by one duplex steam hoist centrally located and operated by one man, which appears to be a saving of both men and power over the plan of having a separate hoist for each derrick. The working parts of a complete derrick are all illustrated in the accompanying figures.

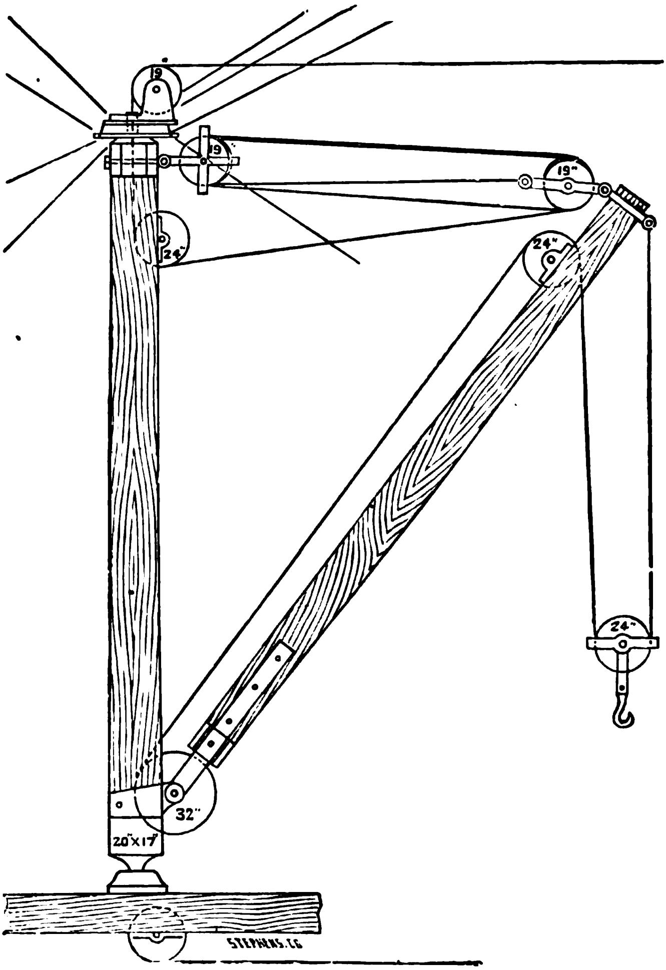


Fig. 7. Sectional view of a boom-lifting derrick, showing the working parts.

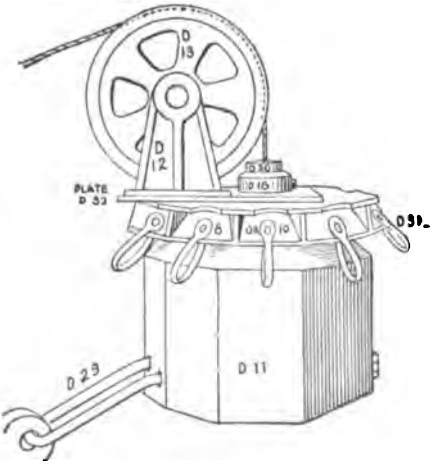


Fig. 8. Top of derrick ready for the guy ropes.

Fig. 7 shows the derrick complete, the rope at the top being the boom rope, or the rope for lifting the boom, that at the bottom the hoisting rope, which lifts the load, independent of the boom. Fig. 8 shows the top of the derrick in detail, ready for the guy ropes. Fig. 9 shows a power hoist of 25 to 30 tons capacity, with all the parts in view. It is arranged with two speeds, both fast and slow. Many of the derricks, especially in the larger quarries, are fitted with a patent derrick turner, the details of which are shown in Fig. 10. Usually it requires a force of several men to turn the derrick, and where the lift is from a deep hole it necessitates a double crew or a waiting for the men to clamber from the quarry and return. With the patent turner one man shifts the boom to any desired point while the load is being lifted, necessitating no loss of time or extra labor. After seeing one of these turners in operation, one wonders why they are not used on all the derricks.

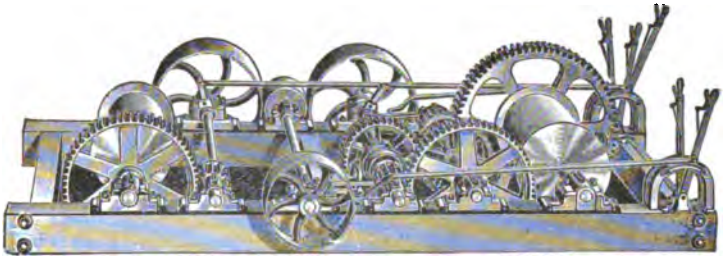


Fig. 9. The New Albany power hoist, with fast and slow speeds.

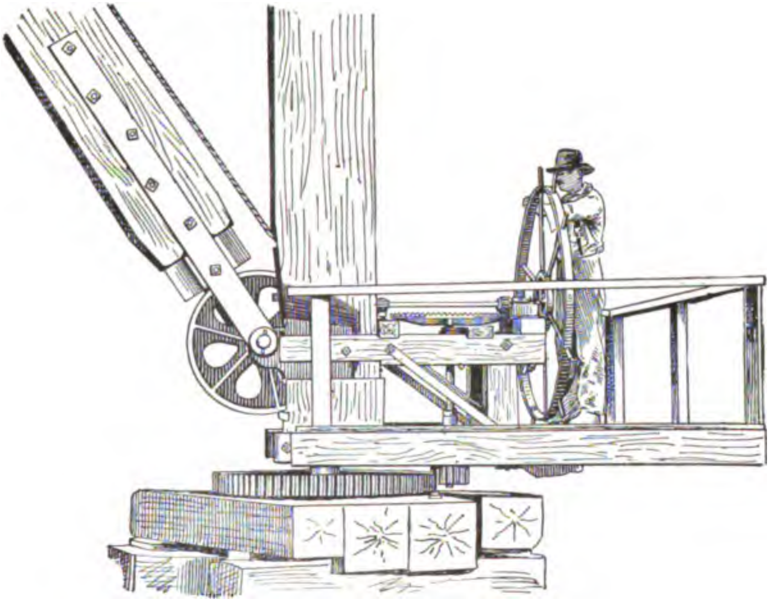
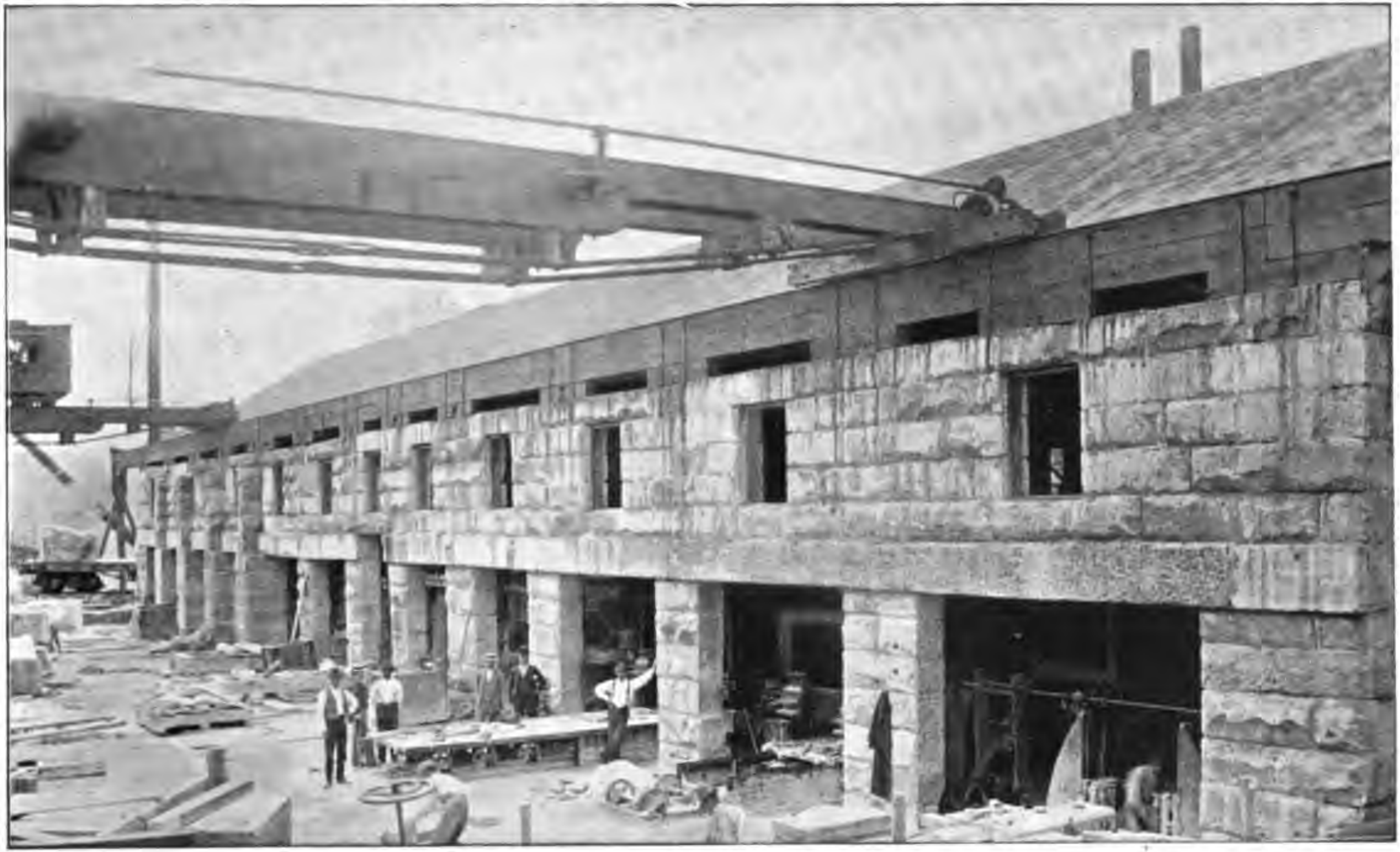


Fig. 10. The New Albany (Lermond) derrick turner, showing method of operation.

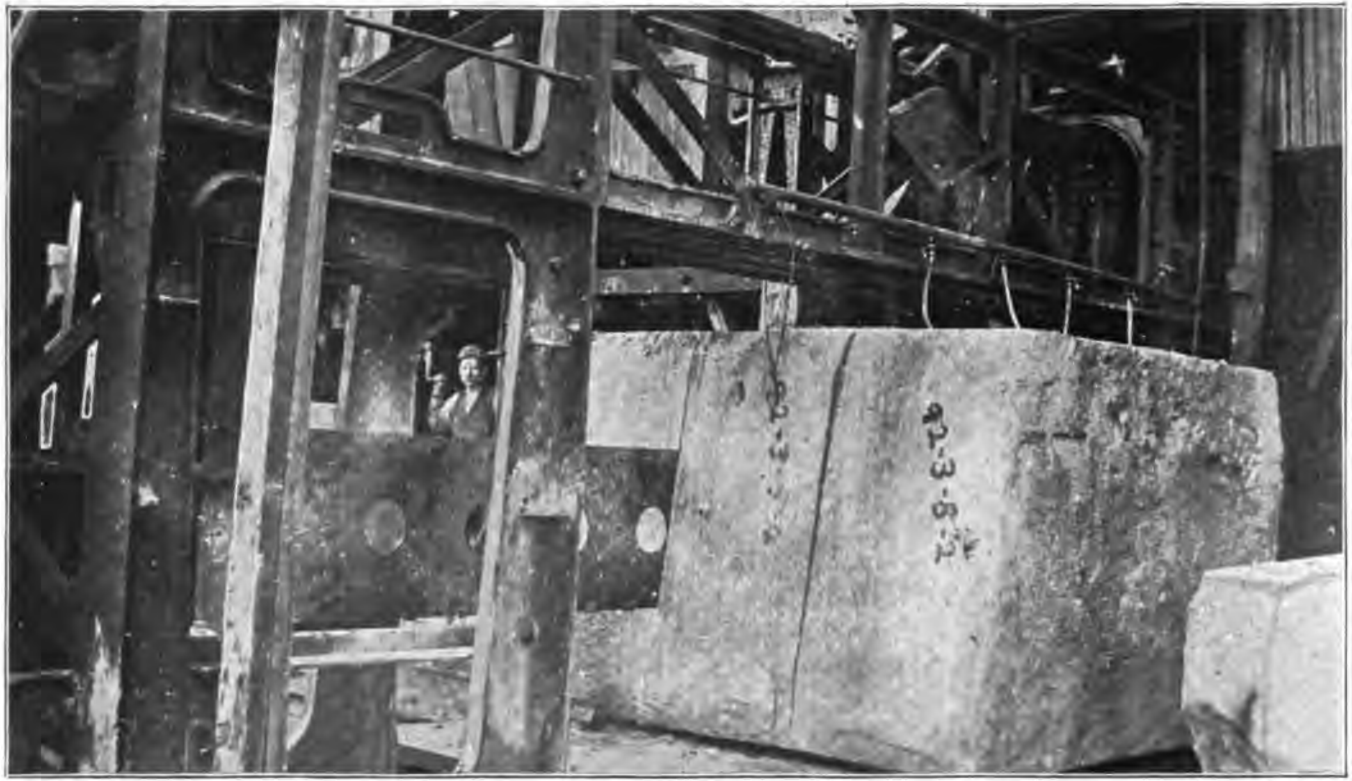
Overhead travelers.—At all the large mills there are overhead travelers running on a high trestlework in front of the mill, having a motion in two directions, parallel to the face of the mill and at right angles to it. These travelers, generally two at each large mill, lift the stone from the railway car and transfer it to the planer or to the saw, and when finished lift it again from the saw to the car or stack it up in the yard. These travelers may be operated by electricity or steam power. The power may be transmitted from the engine in the mill or it may come from a small engine in the car of the traveler.

The overhead wire cableway that is used in the brownstone quarries at Hummelstown, Pa.; at Belleville, N. J., and many other places, and very common in the slate quarries of the east, is not used anywhere in the oölitic region. It is not adapted to use in rectangular or irregular quarries, but might be used with economy in those quarries that have a considerable length of straight face, either along a bluff face or in long, narrow, vertical openings. Their chief advantage over the derrick is where a long, narrow reach, rather than a circular one, is wanted, as in long, deep quarries where the strata dip at high angles and the walls are necessarily sloping, so that a vertical lift is not possible from all parts of the quarry, conditions which do not exist in the oölitic area.

The stone mills are supplied with stone-planers, jointers or headers, turning-lathes and gang-saws, the first two for smoothing the faces by planing off the rough surface and making straight-line moldings; the jointers used for smoothing the surface of the joints in heavy ashlar work; the lathe is the same in principle as the wood or iron lathe used for turning columns. The gang-saw consists of a number of iron blades set in a large frame, generally a tubular iron framework, but sometimes wood, which is given a to-and-fro motion by an eccentric connection with the engines, one power sufficing for 8 or 12 gangs, the framework feeding down automatically. The block of stone to be sawed is placed under the gang of saws, sand and water are supplied on the top of the block, the gang set in motion, and it cuts its way down through the block without any further attention than to keep it supplied with sand and water. This may be done automatically by the sand pump, or the water alone may be allowed to trickle from pipes supplied from a higher reservoir, while the sand is supplied by a workman with a shovel. One man can attend to a number of gangs. So far as observed throughout the region sand is the only abrasive used. Chilled shot, crushed steel and other abrasives frequently used elsewhere are not used here. Chilled shot has been tried several times by different parties, but they claim that even if the stone is well washed with hose, still small particles of the steel will become imbedded in the stone, which, when stacked in the yard, rust and discolor large patches.



STONE SAWING AND PLANING MILL AT HOOSIER QUARRY, SHOWING MILL, PLANERS, TRAVELERS AND YARD.



DIAMOND SAW IN THE MILL OF THE ROMONA OOLITIC STONE COMPANY.

The diamond saw.—The Romona Oölitic Stone Company, in their mill at Romona, Ind., have a large diamond saw, consisting of a heavy steel blade about 12 feet long and 12 inches deep, perforated with a number of holes. The lower edge is set with steel blocks about an inch square and a little thicker than the blade. In the lower edge of the steel blocks are a number of black diamonds that do the cutting. No sand or other abrasive is used with this saw, the cutting being done by the teeth. Water is used as with the gang saw. Plate XXIV gives a view of the diamond saw with the mechanism as far as can be shown on a photograph.

It is a very costly piece of machinery and expensive to keep in operation, owing to wear and loss of the diamonds. It cuts at the rate of about 30 inches per hour, while the ordinary gang saw cuts from three to four inches per hour. It makes a smoother surface than the gang saw, but it is liable to bow and make a curved surface, owing to the diamonds wearing more on one side than on the other. The chief value of the saw is for trimming or squaring large blocks a foot or more in thickness. For slabs ten inches or less the band saw is thought to be as cheap, and for slabs three or four inches thick the band saw is probably cheaper, on account of the greater number of cuts made at one time.

The wire saw or cable channeler.—In the quarry of the Hallowell Stone Co. in Dark Hollow, near Bedford, the wire saw is used for cutting stone from the quarry. This system has been used extensively in Europe, especially in Belgium, it is said, with success, but so far as known to the writer, it has not been used in this country, except in the Vermont marble quarries, where it is said to have been tried and abandoned, and this one in the Dark Hollow quarries. The company refuses to say anything about it, and it is not known whether or not there is any saving over the channeling process. From what could be learned in a visit to the quarry, it did not appear to be a decided improvement, although with a few changes that could easily be made, it might be used economically in the large quarries, along with the channelers, using each in that part of the quarry where it is best adapted.

It consists of an endless three-strand wire about one-quarter inch in diameter, kept in motion by a steam engine and directed by pulleys across the rock where it is desired to make the cut. The cutting is done with sand, as with the band saws, the sand and water being fed on the wire from sand boxes. At either end of the cut the wire rope passes over movable pulleys that feed downward as the wire cuts its way into the rock. The surface cut in this way is generally smoother than the channel face, but it is not always regular, as the cut tends to bow or curve in places where there is any inequality in the stone. The wire runs at a speed of about 1,600 feet per minute, making one revolution in a minute. The wire costs $\frac{7}{8}$ cents per foot, and one wire, 1,600 feet in length, it is said, will make two cuts 30 feet long and 10 feet deep, before it is worn out. The chief defect appears to be the loss of time from the unexpected breaking of the wires.

The core drill.—A very important piece of machinery in exploring a new area is the core drill, or *diamond* drill, but the two terms will probably soon cease to be synonymous. The diamond core drill, as commonly used, consists of a heavy steel ring, the lower edge of which is set with black diamonds. This is screwed on the end of a piece of iron pipe and revolved rapidly by the drill power, which may be hand, horse, steam, electricity or compressed air. As used in the oölitic stone district, steam power is the most common.

Mr. Harbaugh, of Bloomington, states that he dispenses with the diamond drill bit and simply uses gas pipe alone by putting in some chilled shot at the bottom, which does the cutting. He says it drills as rapidly as the diamond drill and is much less expensive, as in case of accident there is no loss but the gas pipe. A core four inches in diameter is the one commonly made, sometimes a smaller one where it is desired to ship by express. A four-inch core not only shows more of the stone, but gives sufficient material for tests of any kind. The cost is the same for a four-inch core as for a smaller one, the common rate in 1896 being $1 to $2.35 per foot, depending upon the amount to be done. The maximum rate of cutting is ten inches per minute or 65 feet per day. The average is about 15 feet per day.

Uses and adaptability of the oölitic limestone.—The bulk of the entire output of all the quarries is used for building stone, for facings, trimmings, ornamentations or foundations. There is a considerable quantity used for monuments, headstones and bases for headstones. One company ships the waste to Chicago for use as flux in the iron furnaces. Another has crushed large quantities of the stone and used it for ballasting the Belt Railroad, now one of the best ballasted roads in the State. The ballast has been carried out a foot or so beyond the end of the ties, and the top layer is of finely ground stone, which has hardened, giving a clean, dustless, solid roadbed. Small quantities of the quarry waste have been used at different places within the last year or two for broken stone for the wagon roads. At several places kilns have been erected for burning lime, but all appear to have fallen into disuse except those at Salem and one at Romona. There is an old abandoned kiln in Bloomington near the old University building, one at Ellettsville, two southwest of Bedford and three south of Bedford along the Monon Railway. The kiln at Romona is said to have burned considerable lime, but was not in operation in July, 1896; later in the fall it was again in operation. The kilns at Salem are the most extensive in the oölitic district, there being five kilns which are said to have been in operation for many years. Three of the kilns were idle in July, 1896, whether temporarily or not is not known. The company refused to give any information regarding the lime product. Hence no figures are available in regard to the quantity of lime burnt, the prices or the uses. Wood, coal and oil have all been tried for fuel. In the summer of 1896 they were using wood.

To see the great quantity of waste rock on the dump piles about the quarries one wonders why more of it is not burnt into lime, and no satisfaction could be obtained to that query when put to the quarrymen. One said it did not make good lime. Another that the lime was too hot, and some had not thought of it, did not know it had ever been tried, or would make lime at all. One only needs to look at the table of analyses on page 320 to see that it would make a fat or rich lime, but that should not be a serious objection, as for many purposes a rich lime is preferred to any other. The reason that more of it has not been burnt may be due to a number of causes: 1. Freight rates, the cost of bringing in the coal and shipping the lime. 2. A prejudice in the local markets against rich lime. 3. Want of a large market, as they are situated in the midst of the Mississippi Valley, with large deposits of limestone on all sides. 4. The lack of some enterprising person to push the business into prominence, as all the stone dealers are interested in the sale of building stone and not lime. The last is probably the most important reason.

The oölitic limestone is best adapted to building purposes, and the bulk of it will always be used for such. It ranks among the best building stones because of the extensive deposit, the ease with which it can be quarried and worked into shape, combined with its great durability and light color. These combine to adapt it to all classes of building, whether rock face, sawed, or tool-dressed face work, plain trimmings, highly carved work, foundations, bridge piers, the heaviest or the most delicate masonry. There is probably not another stone in the markets so well adapted to carved work and so suitable for ornamental cut stone, where richness of color is not essential. It can never rank with the finer marbles, serpentines, etc., where rich coloring is desirable or for purely ornamental purposes, but for decorative carving on the fronts or exterior of buildings, or in larger monumental work it is peculiarly fitted. Probably the stone which most nearly approaches it in this property is the Caen stone from France, which is a softer stone and can be cut or carved more easily, but it is much lighter, more porous and will not stand the rigors of a cold climate like the Bedford stone.

Some of the accompanying illustrations (Plate XXV, and Figs. 11 and 12*) show its adaptability to carving for monumental purposes. Large

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*The cuts for Figs. 11 and 12 were kindly furnished by Mr. John Naugle, Salem, Ind.

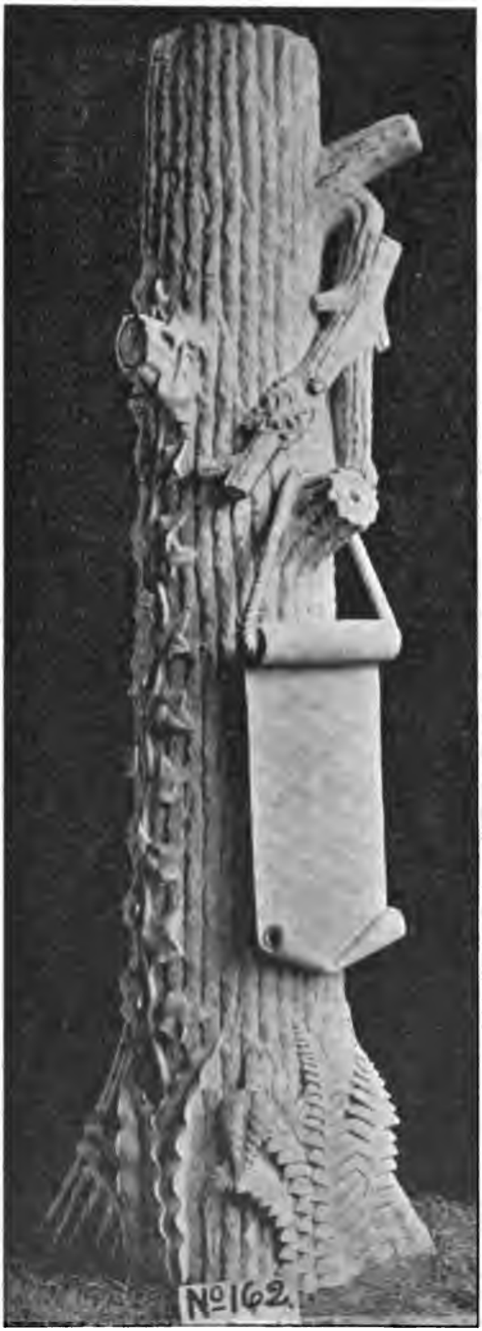


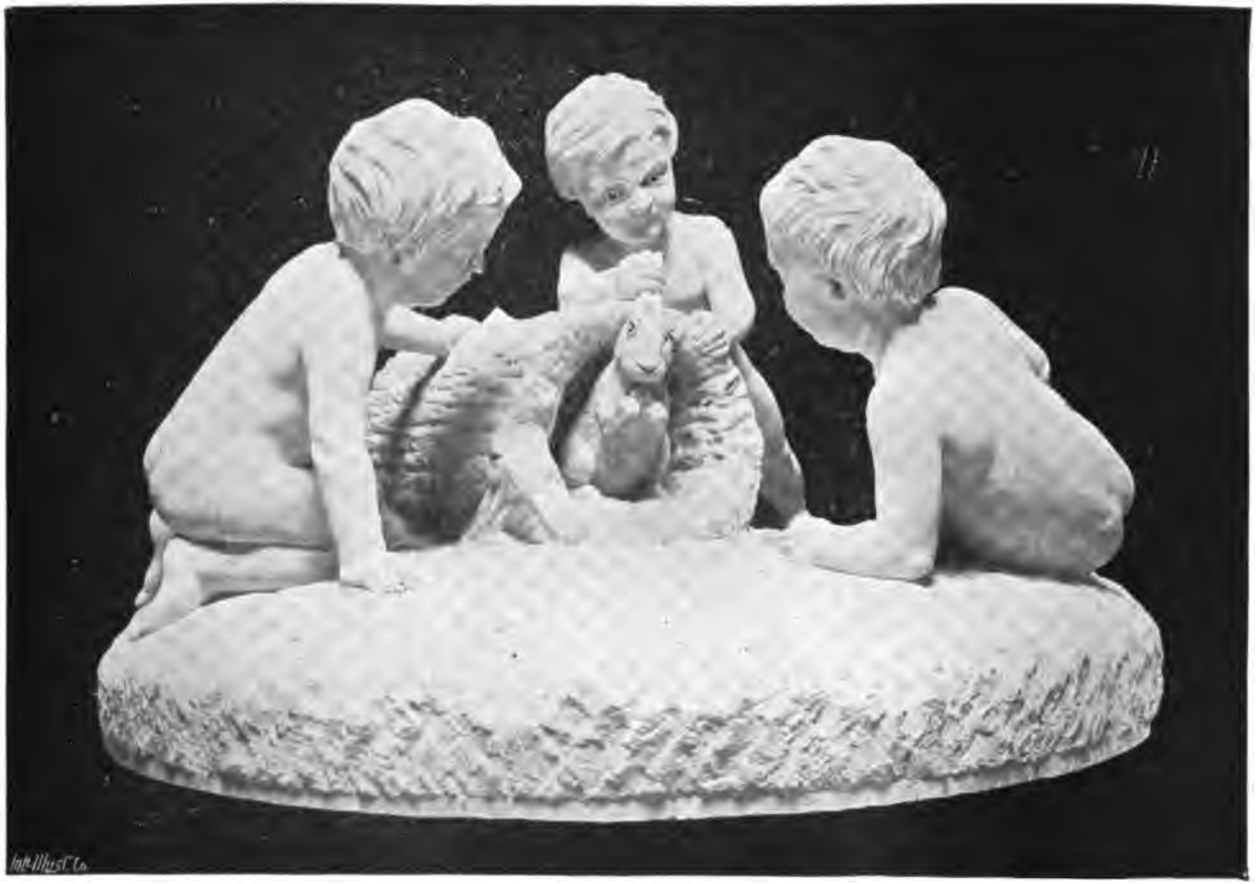
Fig. 11.—Carved from a small single piece of Bedford oölitic limestone, showing its adaptability to carved work.

quantities have been used in this way, both locally and throughout the United States. It may be seen in nearly all the stone and marble yards in Pennsylvania, New York and New Jersey, as well as those throughout the Mississippi Valley States. In the cemeteries at Bedford, Salem and Bloomington, Indiana, there are a great many monuments of handsomely carved work, one of the largest and handsomest being the stonecutters' monument in the new cemetery at Bedford.

The stone has also been used for rustic gateways, hitching posts, rustic chairs, lawn settees and stone animals, and for decorative fireplaces.

It is to be hoped that it will have a more extended use on the wagon roads of the region in which it occurs. While it is not an ideal stone for macadam, it is the best in the region where it occurs, because it is most abundant and most accessible. The waste of the quarries is admirably suited to this purpose, and it could easily be distributed along the railroads, and thus made readily accessible to most of the wagon roads. It could be crushed in a large crusher at the quarry and distributed as crushed

PLATE XXV.



EXECUTED IN A SINGLE BLOCK OF BEDFORD OOLITIC LIMESTONE, SHOWING ADAPTABILITY TO CARVING.

stone, or shipped out in the rough blocks as it comes from the quarry, and crushed by a portable crusher moved from place to place.

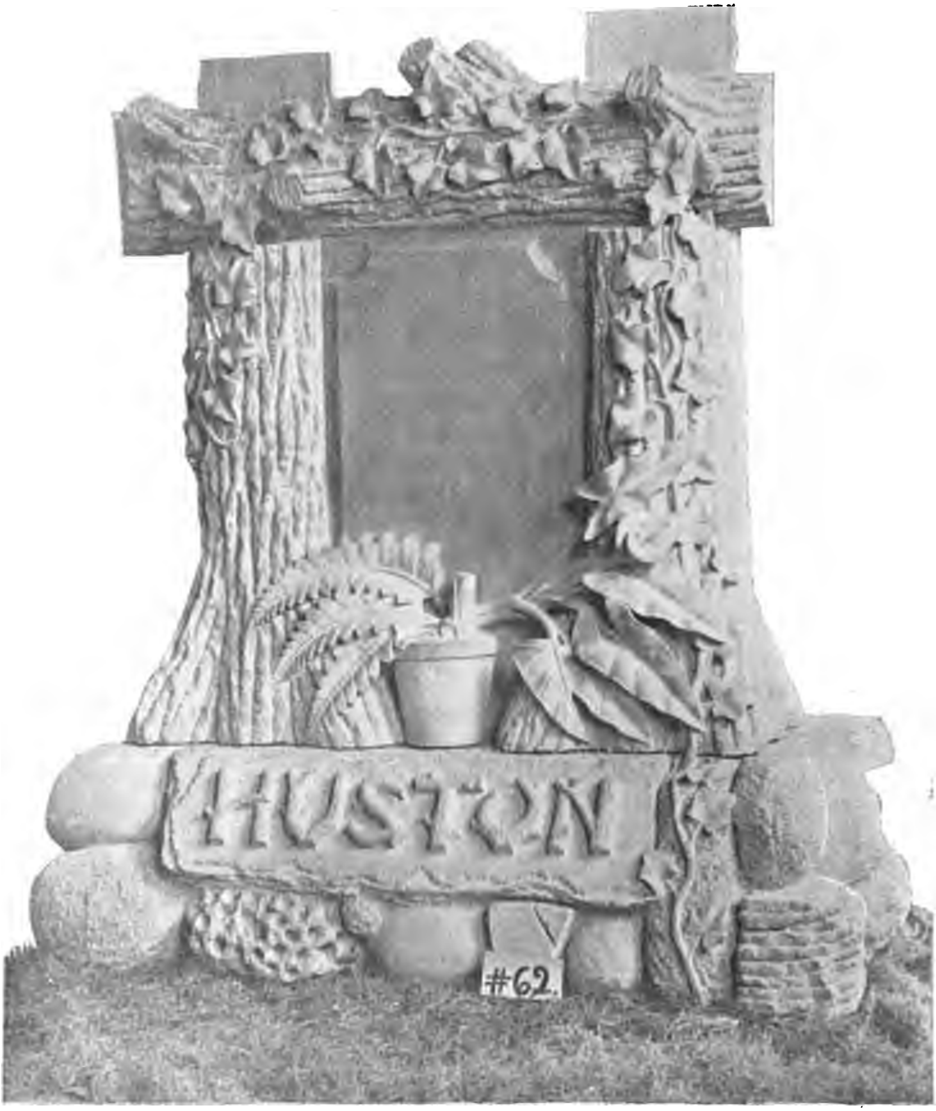


Fig. 12.—Carved from Bedford oölitic limestone, showing its adaptability to fine carving.

The stone makes an excellent bottom for roads, but not the best top dressing, as it grinds to powder under the wheels too readily, makes a light dust and a blinding glare on a bright, sunny day. One is strongly impressed with this blinding strain on the eyes in traveling through Monroe or Lawrence Counties by the great feeling of relief experienced by the eyes when he turns from the white stone road to the yellow-brown dirt roads, especially on a hot summer day. There is a partial compensation for this white glare by the greater ease with which the road can be followed at night.

It can be improved by a thin top dressing of gravel where it can be obtained, or of the geodic quartz so abundant through the region, crushed fine. The top dressing should be thin enough to permit some of the underlying limestone material to work up through it where it will act as a cement and will in the course of time form a hard, smooth surface. A thin coating of siliceous gravel will be found to be profitable, even though it should be necessary to ship it from another part of the State.

The oölitic stone in sawed slabs makes good curbing and flagging. It is sufficiently hard to stand the wear of foot traffic and its granular texture prevents its wearing smooth and becoming slippery in wet weather as marble or compact limestone will do. As the stone is easily sawn into regular slabs, it makes a more even, regular pavement than the natural flagstone, and a more comforable one to walk over.

See Appendix B, at the end of this paper, for list of buildings constructed of Bedford oölitic limestone.

*Transportation facilities.**—Closely identified with, and a potent factor in, the development of the oölitic stone industry are the railways. The New Albany & Salem Railroad (now L., N. A. & C. Ry.), was extended to Bedford in 1852, and through Monroe County in 1854. This road, of course, has been the great means of introducing the Bedford oölitic limestone to the trade. Through Washington, Lawrence and Monroe counties, during the construction of the road, many quarries were opened adjacent to the point where the stone was needed. But when the road was extended still farther toward Chicago, the superficial covering of glacial drift was so deep that exposures of stone were few and far between. The company's quarry, located near the water tank, two miles south of Stinesville, furnished stone for the heavy masonry for the northern division of the line. This road, through its branches, reaches all but ten of the active quarries in the belt.

In 1870 the Indianapolis & Vincennes Railway was built through Owen County, opening up several quarries in the Romona district.

In 1876 the Bedford & Bloomfield (narrow gauge) Railroad (now Bloomfield Branch, L., N. A. & C. Ry.), was built. This road opened the productive Dark Hollow, Reed Station and Buff Ridge districts. In 1895 the road was changed to standard gauge, which has still further increased its usefulness.

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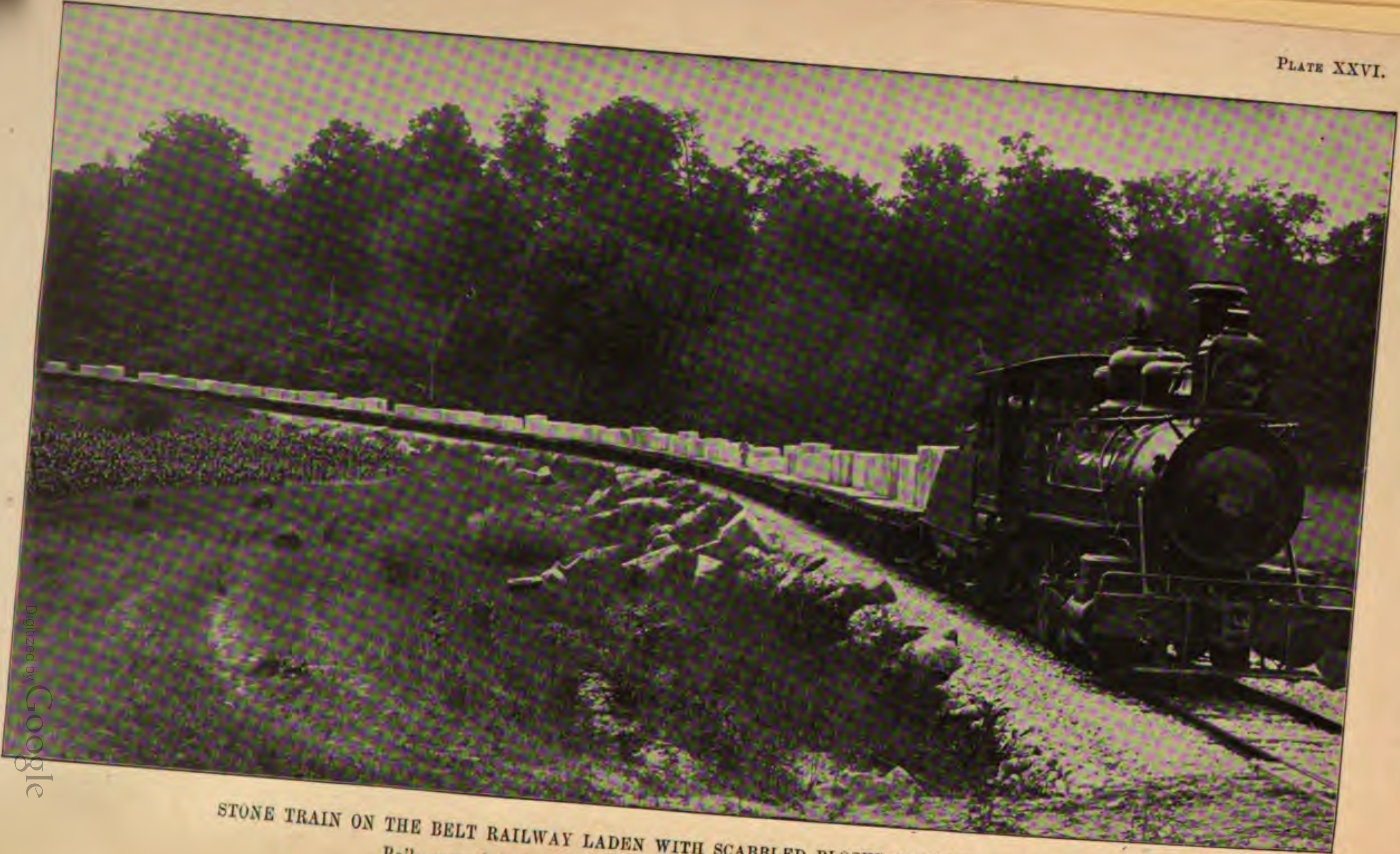
*The data for the greater part of the remainder of this chapter was furnished by Mr. Siebenthal.



STONE TRAIN ON THE BELT RAILWAY LADEN WITH SCABBLED BLOCKS OF OOLITIC LIMESTONE.

Railway track ballasted with oolitic limestone waste from the quarries.

The Ohio & Mississippi (now B. & O. S. W.) Railway, built a branch from Riverdale on White River to the Tanyard Creek quarries in 1890, which was soon afterward extended to Bedford.

The Bedford Belt Railway was built in 1892–3 by the Bedford Quarry Company. When that company was succeeded by the Bedford Quarries Company, the Belt was organized as a separate property under the title Bedford Belt Railway Company. It has connection with many of the larger quarries and with all the railways entering Bedford, and has contributed in no little degree to the development of the stone interests of Lawrence County.

COST OF TRANSPORTATION.

Freight rates per 100 pounds of Oölitic Limestone from Bedford, Ind., to

Chicago	11 cents.	Detroit	12 cents.
St. Louis	10 cents.	Milwaukee	12½ cents.
Kansas City	21 cents.	Pittsburgh	18 cents.
Louisville	5 cents.	Philadelphia	26 cents.
Cincinnati	6 cents.	New York	28 cents.
Cleveland	15 cents.	Boston	30 cents.
New Orleans	21 cents.	Buffalo	18 cents.
Atlanta	21 cents.	Chattanooga	19 cents.

Prices of oölitic limestone.[*]—Before 1877 no channelers were in use in the oölitic belt, and as a consequence the stone coming from the quarries just as it was blasted out was marketed in very rough blocks, unless scabbled to special dimensions. About 1866, James Needham, operating the Salem quarries, sold rough quarry or mill blocks at 25 cents per cubic foot, f. o. b. at quarry. At the same time the Ellettsville quarries were selling at 35 cents per cubic foot for similar blocks and 45 cents per cubic foot for scabbled blocks in small dimensions. Scabbled blocks of large or unusual dimensions ranged up to $1 per cubic foot. The stone which went into the Illinois State House was billed at $1.

For sawed ashlar (sawed on two sides) the price was from 60 cents to 80 cents, and for stone sawed on four sides, 90 cents to $1.10. These prices prevailed up to 1872–3.

In 1873 the Marion County court-house was constructed at 30 cents per cubic foot for mill blocks f. o. b. at quarry, and this price prevailed without much variation up to 1877.

In 1878 the Indiana State Capitol was contracted at 25 cents per cubic foot.

In 1881 the prices were: Mill blocks, 25 cents per cubic foot; scabbled dimension stone, 30 to 35 cents; sawed, two sides, 55 cents; four sides, 75 cents.

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[*] The data concerning prices was furnished by Mr. Siebenthal through the kindness of Maj. Perry, of Bloomington.

By 1891 prices had gradually declined *pari passu* with improved quarry methods and machinery until mill blocks were worth 20 cents, dimension blocks 25 to 30 cents; sawed, two sides, 35 cents; four sides, 50 cents.

These prices by general agreement were maintained until October, 1895, since which time each quarry has fixed its own prices.

Prices to-day are: Mill blocks, 11 to 20 cents; dimension blocks, 20 to 25 cents; sawed, two sides, 28 to 35 cents; four sides, 43 to 50 cents.

The Indiana Oölitic Stone Association was organized March 5, 1895, for the advancement of the mutual interests of the oölitic limestone quarrymen, and, among other things, to establish a uniform scale of prices. The association continued in existence about a year, but in October, 1895, by the withdrawal of several of the larger firms, the established scale of prices was demolished, as noted above.

The Indiana oölitic quarrymen generally have been members of the Ohio Valley Quarrymen's Association, The Chicago Quarryman's and Cut Stone Contractors' Association. The latter association has held prices up in Chicago, and a similar organization in New York city has held prices up there also.

STATISTICS OF THE BEDFORD OÖLITIC LIMESTONE PRODUCTION IN INDIANA FOR THE YEARS 1895 AND 1896.

Number.	ITEM.	Northern district—Romona, Big Creek, Stinesville, Ellettsville.	Middle district—Bloomington, Hunter Valley, Sanders.	Southern district—Bedford, Dark Hollow, Reed's Station, Oölitic, Peerless, Paradise, Heltonville, Salem.	Mills in Indianapolis.	TOTAL.
1	Cubic feet of stone produced in 1895	1,295,000	1,812,716	3,020,591	. . . .	6,138,307
2	Cubic feet of stone produced in 1896	673,000	1,343,926	3,438,656	. . . .	5,455,582
3	Value of stone produced in 1895	$311,875	$420,487	$771,468	$19,430[1]	$1,523,260
4	Value of stone produced in 1896	$165,697	$294,635	$725,883	$23,417[1]	$1,209,632
5	Capital invested in 1896	$197,700	$458,400	$1,337,000	$26,500	$2,319,600
6	Number of men employed in 1895	473	424	825	62	1,784
7	Number of men employed in 1896	315	374	787	60	1,536
8	Number of quarries in operation recently	12	15	21	. . . .	48
9	Number of channeling machines in operation	19	39	78[1]	. . . .	136
10	Number of channeling machines idle	11	7	11	. . . .	29
11	Number of steam drills in operation	15	15	44	. . . .	74
12	Number of steam drills idle	4	3	5	. . . .	12
13	Number of derricks in operation	24	29	49	1	103
14	Number of derricks idle	6	3	8	. . . .	17
15	Number of derrick turners in use	3	10	24	. . . .	37
16	Number of planers and jointers	6	3	16	4	29
17	Number of saw gangs in operation	32[2]	32	68	11	143
18	Number of saw gangs idle	9	. . . .	9	. . . .	18
19	Number of steam and electric travelers	4	3	12	1	20
20	Number of lathes in operation	4	. . . .	6	. . . .	10
21	Number of limekilns in recent operation	1	. . . .	5	. . . .	6
22	Number of abandoned limekilns	2	2	5	. . . .	9

[1] And one wire saw or cable. [2] And one diamond saw.

STATISTICS OF OÖLITIC LIMESTONE QUARRIES.*

LOCATION.	Total wages paid.	Number of men employed.	Number of boys employed.	Highest wages paid skilled labor.	Lowest wages paid skilled labor.	Highest wages paid unskilled labor.	Lowest wages paid unskilled labor.	Average daily wages paid boys.	Number of hours cons. a day's work.
Bedford	$267,159	846	41	$2 79	$1 90	$1 58	$1 22	$0 91	10
Bloomington	41,451	116	4	2 40	1 68	1 38	1 10	1 00	10
Sanders	19,371	103	2	3 25	1 62	1 50	1 25	75	10
Ellettsville	26,164	75	.	2 75	1 35	1 32	1 00	. .	10
Stinesville	53,425	132	5	2 93	2 00	1 50	1 12	75	10
Romona	35,750	159	3	3 33	2 00	1 53	1 30	75	10
Total	$143,320	1,431	55	. . .	. . .	. . .	. .	. .	. . .

*From Indiana Bureau of Statistics, Bulletin No. 7.

Statements showing location of stone quarries, capital invested, value of stone quarried, men employed:*

Location.	No. of quarries.	No. of acres in quarries.	Value buildings and grounds.	Kind of stone.	Principal use of stone.	Number of cars quarried.	Total value.	Av. No. months in operation.
Bedford	11	1,710	$1,370,800	Buff, blue, brown oölitic limestone	Buildings	10,513	$694,012	9.4
Bloomington	5	223	111,000	" "	Building, monuments, etc	2,185	68,700	8.6
Sanders	3	185	220,000	" "	" "	740	37,200	8.3
Ellettsville	2	80	75,000	" "	" "	736	81,568	10
Stinesville	4	357	208,000	" "	" "	1,712	140,410	10.5
Romona	3	122	158,000	" "	" "	1,127	89,060	8.6
Total	28	2,677	$2,142,800	. . . .	. . . .	17,013	$1,110,950	. .

*The Indiana Bureau of Statistics, 1896, Bulletin No. 7,

Machinery in use in the oölitic limestone quarries in 1891:*

Steam channelers	78
Steam drills	54
Saw gangs	57
Derricks	74
Overhead travelers	12

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*Compiled from 17th Annual Report State Geologist of Indiana.

List of the Bedford Oölitic Limestone Quarries, giving the name of the quarry, the location, the date opened, the years operated and the companies operating the same.

ROMONA DISTRICT.			
Eagle Quarry	10 N, 3 W, sec. 3, N E.	1875	"Eagle Stone Werks," Rockwell & Co., Romona, Ind.
Lilly Quarry	10 N, 3 W, sec. 3, S E	1890-1897	Oölite Quarry Co., Indianapolis, Ind.
Kersler Quarry	10 N, 3 W, sec. 3, S E	1874-1885	Gosport Stone and Lime Co., Romona, Ind.
		1885-1897	Romona Oölitic Stone Co., Indianapolis, Ind.
Bienert Quarry	10 N, 3 W, sec. 10, N W	1870-1896	White River Stone and Lime Co., Simpson & Archer, Spencer.
		1896-1897	Keever Stone Co., Columbus, O.
Bladen Quarry	10 N, 3 W, sec. 10, S W	1876 (?)	E. R. Bladen, Romona, Ind.
Railroad Quarry	10 N, 3 W, sec. 10, S W	1870	I. & V. Ry. Co., ——— ———.
State House Quarry	10 N, 3 W, sec. 22, N E N W	1878-1879	Kannamaker & Denig, Indianapolis, Ind.
STINESVILLE DISTRICT.			
North Bedford Quarry	10 N, 2 W, sec. 17, S E N W	1889-1897	North Bedford Stone Co. (In receiver's hands.)
Big Creek Quarry	10 N, 2 W, sec. 17, N W S W	1854-1868	Biddle, Watts & Co., Pittsburgh, Pa.
		1889-1895	Big Creek Stone Co., Stinesville.
		1895-1897	Indiana Steam Stone Works, Bloomington.
Old Terre Haute Quarry	10 N, 2 W, sec. 17, S W S E.	1880-188(?)	Corner & Davis, Stinesville, Ind.
		188(?)-1892	Terre Haute Stone Works, Terre Haute, Ind. (Lyne & Chadwick).
		1892-1897	Oölite Quarry Co., Indianapolis, Ind.
Walden Quarry	10 N, 2 W, sec. 17, N W S E.	1880	Wickliff Walden, Stinesville, Ind.
John McHenry Quarry	10 N, 2 W, sec. 17, S E S W.	1880	John McHenry, Stinesville, Ind.
Griswold Quarry	10 N, 2 W, sec. 20, N W N E	1880-1890	Chas. Eppinghausen, Stinesville, Ind.
		1890-1897	Indiana Oölitic Limestone Co., Chicago, Ill.
Malone & Pickel Quarry	10 N, 2 W, sec. 20, S W N E.	1889-1895	Stinesville and Bloomington Stone Co., Stinesville.
		1895-1897	Stinesville Stone Co., Chicago.
Ellettsville Quarry	10 N, 2 W, sec. 20, S W N E.	1891-1897	Ellettsville Stone Co., Ellettsville, Ind.
Terre Haute Quarry	10 N, 2 W, sec. 21, N E N W	188(?)-1892	Terre Haute Stone Works, Terre Haute, Ind.
		1892-1897	Oölite Quarry Co., Indianapolis, Ind.
Railroad Quarry	10 N, 2 W, sec. 20, S E S E	1853-1856	New Albany & Salem Railroad.

List of the Bedford Oölitic Limestone Quarries—Continued.

ELLETTSVILLE DISTRICT.

Preacher's Quarry	10 N, 2 W, sec. 28, N W S W	1872-1875	Cornelius, Ellettsville, Ind.
Matthews' Lower Quarry	10 N, 2 W, sec. 28, N W S E	1872-1875	John Matthews & Sons, Ellettsville, Ind.
Kelley's Quarry	10 N, 2 W, sec. 28, S W S E.	1872-1875	C. F. Kelly & Perry Bros., Ellettsville, Ind.
Kostenbader's Quarry	9 N, 2 W, sec. 3, N E N W.	1864-1875	John Kostenbader & Co., Ellettsville, Ind.
Perry's Old Quarry	9 N, 2 W, sec. 3, S E N W	1866-187(?)	Perry Bros., Bloomington, Ind.
Matthews' Upper Quarry	9 N, 2 W, sec. 3, N E S W	1862-1897	Matthews Bros., Ellettsville, Ind.
Hight Quarry	9 N, 2 W, sec. 3, S E S W	1869-137(?)	Sharp & Hight, Ellettsville, Ind.
		187(?)-1897	Matthews Bros., Ellettsville, Ind.
Perry's New Quarry	9 N, 2 W, sec. 3, S W S E	187(?)-1895	G. K. Perry, Bloomington, Ind.
Perry's No. 3 Quarry	9 N, 2 W, sec. 3, S E S E.	1896-1897	G. K. Perry, Bloomington, Ind.

HUNTER VALLEY DISTRICT.

Hunter Quarry (Consolidated No. 2)	9 N, 1 W, sec. 30, S W N E & N W S E	1890-1896	Morton C. Hunter Stone Co., Bloomington, Ind.
		1896-1897	Consolidated Stone Co., Chicago.
Johnson Quarry	9 N, 1 W, sec. 20, N E	1892-1897	Chicago & Bloomington Stone Co., Bloomington, Ind.
Norton Quarry (Consolidated No. 1)	9 N, 1 W, sec. 30, N E S E	1892-1895	Norton Stone Co., Bloomington, Ind.
		1835-1897	Consolidated Stone Co., Chicago.
Crescent Quarry	9 N, 1 W, sec. 29, N W S W	1893-1897	Perry, Matthews & Perry, Bloomington, Ind.
Star Quarry	9 N, 1 W, sec. 29, N W N W	1895-1897	Star Stone Co., Bloomington, Ind.
Hunter Bros.' Quarry	9 N, 1 W, sec. 30, N E N E.	1895-1897	Hunter Bros.' Stone Co., Bloomington, Ind.
Hunter Valley Quarry	9 N, 1 W, sec. 29, S W N W	1895-1897	Hunter Valley Stone Co., Bloomington, Ind.

BLOOMINGTON DISTRICT.

Bloomington Oölitic Stone Co. Quarry	City of Bloomington	1889-1895	Bloomington Oölitic Stone Co., Bloomington, Ind.
		1895-1897	Henley Stone Co., Bloomington, Ind.
Central Quarry	City of Bloomington	1891-1897	Central Oölitic Stone Co, Bloomington, Ind.

SANDERS DISTRICT.

Reed's Oölitic Quarry	8 N, 1 W, sec. 33, N W S E	1888-1897	Oölitic Stone Co., of Indiana, Bedford, Ind.
Adams' Quarry	8 N, 1 W, sec. 33, N E S W	1889-1897	Monroe County Oölitic Stone Co., Bloomington, Ind.
Reed's Bedford Quarry	8 N, 1 W, sec. 33, N E S E	1891-1897	Bedford Quarry Co., Bedford, Ind.
Empire Quarry	8 N, 1 W, sec. 33, S E N W	1892-1897	Empire Stone Co., Bloomington, Ind.
Tomlinson Quarry	8 N, 1 W, sec. 33, S E S E	1892-1897	John Tomlinson & Son, Chicago.
B. & B. Quarry	8 N, 1 W, sec. 28, S E S W.	1893-1896	Bloomington-Bedford Stone Co., Chicago.
		1896-1897	Acme-Bedford Stone Co., Chicago.
Mathers' Quarry	8 N, 1 W, sec. 33, N E N E.	1895-1896	Mathers Stone Co., Bloomington, Ind.
		1896-1897	Henry Woollery, Bloomington, Ind.

CLEAR CREEK DISTRICT.

Cleveland Quarry	7 N, 1 W, sec. 20, S E N W	1886-1886	R. F. McKinley, et al., Bedford, Ind.
		1886-1897	Cleveland Stone Co., Cleveland, Ohio.
Buff and Blue Oölitic Stone Co	Bloomington		Have no quarries in operation, but own much land along Clear Creek valley.
Crafton Stone Co.	Bloomington		

PEERLESS DISTRICT.

Peerless Quarry	6 N, 1 W, sec. 26, S E N W	1890-1897	Peerless Stone Co., Bedford, Ind.
Thornton Quarry	6 N, 1 W, sec. 34, N E N E	1895-1897	Bedford Steam Stone Works, Bedford, Ind.

BUFF RIDGE DISTRICT.

P. M. & B Quarry	6 N, 1 W, sec. 33, S W N E	1889-1897	Perry, Matthews & Buskirk, Bedford, Ind.
Hoosier No. 2 Quarry	6 N, 1 W, sec. 33, S E N E	1885-1892	Hoosier Stone Co., Bedford, Ind.
		1892-1894	Bedford Stone Quarries Co., Bedford, Ind.
		1894-1897	Bedford Quarries Co., Chicago, Ill.
Buff Ridge Quarry	6 N, 1 W, sec. 33, N W S E.	1891-1892	Hoosier Stone Co., Bedford, Ind.
		1892-1894	Bedford Stone Quarries Co., Bedford, Ind.
		1894-1897	Bedford Quarries Co., Chicago, Ill.
Oölitic Quarry	6 N, 1 W, sec. 32, S E S E.	1885-1892	Bedford Oölitic Stone Co., Bedford, Ind.
		1892-1894	Bedford Stone Quarries Co., Bedford, Ind.
		1894-1897	Bedford Quarries Co., Chicago, Ill.

List of the Bedford Oölitic Limestone Quarries—Continued.

BUFF RIDGE DISTRICT—Continued.

Brickyard Quarry	6 N, 1 W, sec. 33, S W S W	1884(?)-1887(?)	
		1887-1892	Bedford Oölitic Stone Co., Bedford, Ind.
		1892-1894	Bedford Stone Quarries Co., Bedford, Ind.
		1894-1897	Bedford Quarries Co., Chicago, Ill.
Heosier Quarry	6 N, 1 W, sec. 33, S W	1883-1892	Hoosier Stone Co., Bedford, Ind.
		1892-1894	Bedford Stone Quarries Co., Bedford, Ind.
		1894-1897	Bedford Quarries Co., Chicago, Ill.
Reed's Quarry	5 N, 1 W, sec. 5. N E	1882-1897	Bedford Quarry Co., Bedford, Ind.
Bedford, Indiana, Quarry	5 N, 1 W, sec. 5, S E N E	1885-1891	Crim, Duncan & Co., Bedford, Ind.
		1891-1892	Indiana Stone Co., Bedford, Ind.
		1892-1894	Bedford Stone Co., Bedford, Ind.
		1894-1897	Bedford Indiana Stone Co., Indianapolis, Ind.

DARK HOLLOW DISTRICT.

Dark Hollow Quarry	5 N, 1 W, sec. 8, N W N E	1878-1890	Dark Hollow Stone Co., Bedford, Ind.
		1890-1894	Dark Hollow Quarry Co., Bedford, Ind.
		1894-1897	Consolidated Stone Co., Chicago, Ill.
Consolidated Quarry No. 4	5 N, 1 W, sec. 5, S W S E	1895-1897	Consolidated Stone Co., Chicago, Ill.
Consolidated Quarry No. 5	5 N, 1 W, sec. 5, N W S W	1896-1897	Consolidated Stone Co., Chicago, Ill.
Hallowell Quarry	5 N, 1 W, sec. 5, S E S W	1878-1882	Hinsdale-Doyle Granite Co., Chicago, Ill.
		1882-1897	Hallowell Stone Co., New York.
Thornton Quarry	5 N. 1 W, sec. 5, N E S W	1886-1893	Bedford Steam Stone Works, Bedford, Ind.
Baalbec Quarry	5 N, 1 W, sec. 9, S E	1879(?)	Wilson, Dunn & Co., Bedford, Ind.
		1890-1894	Operated by Acme-Bedford Stone Co., Chicago, Ill.

SPIDER CREEK DISTRICT.

Gowan or Limekiln Quarry	5 N, 1 W, sec. 28, N E N E	1891-1897	Bedford Building Stone Co., Bedford, Ind.
C. S. Norton Quarry	5 N, 1 W, sec. 22, N W N E	1888-1895	Cosner & Norton, Bedford, Ind.
		1895-1897	C. S. Norton Blue Stone Co., Bedford, Ind.
West Bedford Quarry	5 N, 1 W, sec. 22, N E N E	1892-1897	West Bedford Stone Co., Bedford, Ind.

BEDFORD AND VICINITY.

Standard Quarry	5 N, 1 W, sec. 11, S W N W	1893-1897	Standard Stone Co., Bedford, Ind.
Salem-Bedford Quarry	5 N, 1 W, sec. 12, S W N W	1892-1897	Salem-Bedford Stone Co., Louisville, Ky.
Brown Quarry	5 N, 1 W, sec. 12, N E S W	1890-1897	Bodenschatz-Bedford Stone Co., Chicago.
Blue Hole Quarry	5 N, 1 W, sec. 13, S E S W	185(?)-1878	Nathan Hall & Davis Harrison, Bedford, Ind.
		1878-188(?)	Hinsdale Doyle Granite Co.
		188(?)-1897	Chicago & Bedford Stone Co., Bedford, Ind.
Benzels Quarry	5 N, 1 W, sec. 24, N E N W	1890-1897	Bedford Blue Stone Co., Chicago.
Glover's Quarry	5 N, 1 W, sec. 23, S E S W	185(?)-	John Glover, Bedford, Ind.
Johnson Quarry	5 N, 1 W, sec. 23, N E S W	-187(?)	D. Johnson, Bedford, Ind.
Coats Quarry	5 N, 1 W, sec. 23, S W S W	-187(?)	
Heltonville Quarry	6 N, 1 E, sec. 25, S E of N W	1890-1897	Heltonville Oölitic Stone Co., Evansville, Ind.
Mitchell Hollow Quarry	5 N, 1 E, sec. 30, S W S W	1890-1892	Tanyard Stone Co., Bedford, Ind.
		1892-1893	Bedford Stone Co., Bedford, Ind.
Tanyard Quarry	5 N, 1 E, sec. 31, S W	1890-1892	Tanyard Creek Stone Co., Chicago.
		1892-1895	White River Stone Co., Chicago.
		1895-1897	Bedford Sterling Stone Co., Chicago.

ROCK LICK DISTRICT.

Big Four Quarry	4 N, 1 E, sec. 30, S E N W	1889-1889	Big Four Stone Co., Mitchell, Ind.
Leeds, Chanler & Storrs Quarry	4 N, 1 E, sec. 30, S W N E	1890-1890	Leeds, Chanler & Storrs, Chicago.

SALEM.

Salem Quarry			Salem-Bedford Stone Co., Louisville, Ky.
Twin Creek Quarry			Twin Creek Stone and Land Co.

INDIANAPOLIS.

The following have mills only:

J. C. Schmid & Sons, 329 Bates Street. Uses stone from the Peerless, the P., M. & B. and G. K. Perry's quarries.
G. Illenbach & Co., 150 Harrison Street.
Klink & Matthews, Kentucky Avenue and White River. Stone from the P., M. & B. quarry.

The records show that many other companies were incorporated in the years 1890 and 1891, which exist only in name, which have no holdings of real estate, yet which have kept up their organization. Some of these were *bona fide* companies intending to do a quarry business, but headed off by the business depression; others were for speculative purposes pure and simple; still others were organized to take advantage of a lax law governing the incorporation of companies, and to preëmpt, or copyright, as it were, certain felicitous combinations of the words "Bedford" and "Oölitic" limestone.

Among these were the *Bedford Limestone Co.*, *Auditorium Bedford Stone Co*, *United States Stone Co.*, *Bedford Stone Co.*, *Central Bedford Stone Co.*, *Indiana Limestone Co.*, *Bedford Stone Mill Co.*, and *Union Stone Co.* Of these the *United States Stone Co.* owns lands lying three-quarters of a mile northeast of the Bodenschatz and Salem-Bedford quarries, and expects to open a quarry next season. The *Bedford Stone Mill Co.* above must not be confounded with the *Bedford Stone Mill Co.* which was organized in 1895, and which operates the fine new mill near the crossing of the L., N. A. & C. Ry. and E. & R. Ry.

CHAPTER III.

LOCAL FEATURES OF THE BEDFORD OÖLITIC LIMESTONE AND DESCRIPTION OF THE QUARRIES.*

T. C. H. AND C. E. S.

ROMONA AND VICINITY.

The quarries at Romona are the most northern ones in the oölitic stone belt, occurring near the northern limit of the oölite, as shown on the accompanying map. Romona is on the north branch of the White River, on the Indianapolis & Vincennes division of the Pennsylvania Railroad. There is one quarry operating extensively, another on a smaller scale, and several abandoned ones.

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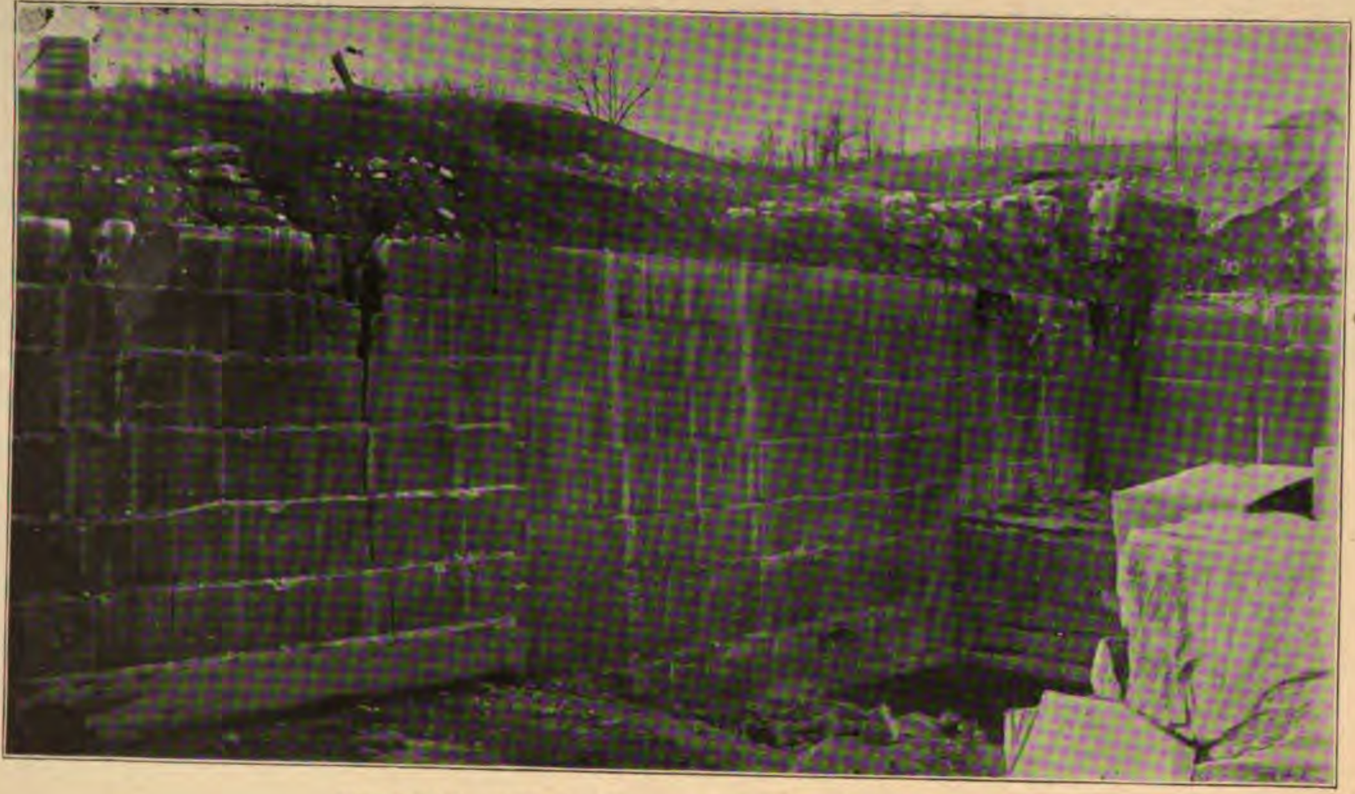
*Mr. Siebenthal is responsible for the historical part of this chapter, Mr. Hopkins for the descriptive part.



SOUTH FACE OF ROMONA OOLITIC STONE COMPANY'S QUARRY.

The Romona Oölitic Stone Co.'s quarry.—The quarry belonging to the Romona Oölitic Stone Company was opened by the Gosport Stone and Lime Company about 1868, and has been operated by the present company since 1885. It works a greater thickness of stone than any other quarry in the oölitic region, having nine channel cuts, not less than 60 feet of sound stone exclusive of the stripping.

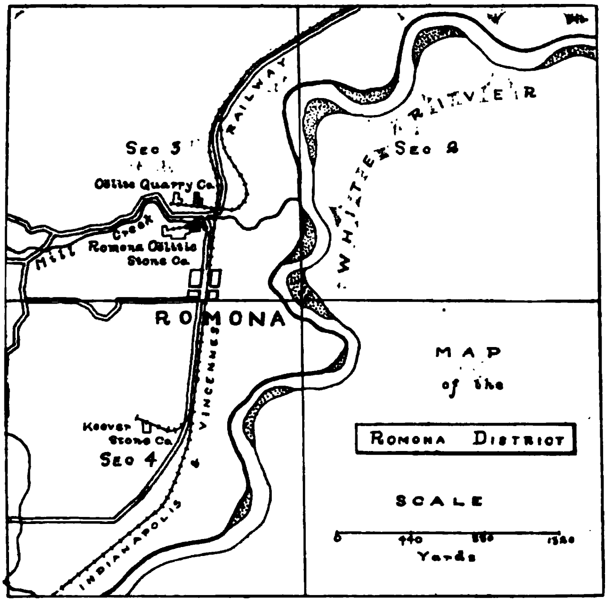


Fig. 13.—Showing location of the Romona quarries.

The stripping varies from zero at one end to 30 or 40 feet at the other, and consists of soil six to eight feet, a hard, semi-oölitic, stylolitic limestone 20 to 25 feet and a compact argillaceous limestone three to five feet. The upper 40 feet of the quarry are buff and the bottom 20 feet blue; but, as in other quarries, the line between the blue and buff is not regular, the blue increasing in thickness toward the west where the covering is thicker. The blue stone is said to be underlain by a few feet of hard, gray, siliceous limestone, underlain in turn by a light cream colored fossiliferous limestone, as shown in a drilling in the bottom of the quarry.

The stone is coarser grained than most of the stone in the Bloomington-Bedford region, also more crystalline and less oölitic. It is about the same in hardness and ease of working as the finer grained, but from the fact of its coarse grain it is not so much sought after for building stone, and a larger proportion of it is used for bridge work and heavy masonry.

There are a few east-west joint seams but no cross (north-south) seams were observed. In some places, as may be seen on the accompanying illustration, the rock has weathered along these seams, forming considerable openings. Fortunately there are not many such, so that the waste from this cause is not great. There are numerous bedding seams in the hard rock overlying the oölitic, but in the quarry rock only two stylolite (crowfeet) seams were observed, and these were near the bottom. The stone is cross-grained in a few places, the cross-grain dipping north in nearly all cases.

CHEMICAL ANALYSIS OF THE ROMONA OÖLITIC LIMESTONE.*

		Per Cent.
Lime (CaO)	54.82	
Lime carbonate ($CaCO_3$)		97.90
Magnesia (MgO)	.31	
Magnesia carbonate ($MgCO_3$)		.65
Ferric oxide and alumina	.18	
Carbon dioxide (CO_2)	43.49	
Insoluble residue (SiO_2, etc.)	1.26	
Total	100.06	
Specific gravity	2.48	

Sample for analysis dried at 135 C.

CRUSHING TESTS OF ROMONA OÖLITIC LIMESTONE.†

No. 1. 6,800 pounds per square inch broke with 2 good pyramids.
No. 2. 6,400 pounds per square inch broke with 2 good pyramids.
No. 3. 7,800 pounds per square inch broke with 2 good pyramids.
No. 4. 11,200 pounds per square inch broke with 2 good pyramids.
Absorption 1–39 or 2.59 per cent.

No. 4 was said to be on edge, which is commonly supposed to be a much weaker position for the stone. The probable reason for its greater strength is that it was quarried in 1895 and hence much better seasoned than the other specimens, which were quarried in 1896, but a few months or weeks before they were tested.

The quarry is close to the Indianapolis & Vincennes Railroad and has a branch from the quarry and the mill to that road. The quarry is well equipped with channelers, steam drills, derricks, steam hoists and a well-furnished mill. The mill contains saw-gangs, planers, jointers and diamond saw for cutting and working the stone, and two overhead travelers for handling it. There are also a large number of stonecutters at work finishing the stone by hand.

The accompanying illustrations, Plate XXVII and Fig. 14, represent different parts of the Romona quarry, showing the thickness of the stone, the amount of stripping and the vertical weather seams.

The diamond saw used here is the only one in the oölitic region. It is said to cut at the rate of about 33 inches per hour, sometimes as high as 40 and sometimes as low as 20 inches, while the ordinary band-saw cuts at the rate of three or four inches per hour. It leaves a smooth and more regular surface, but the saw is liable to bow and make a curved

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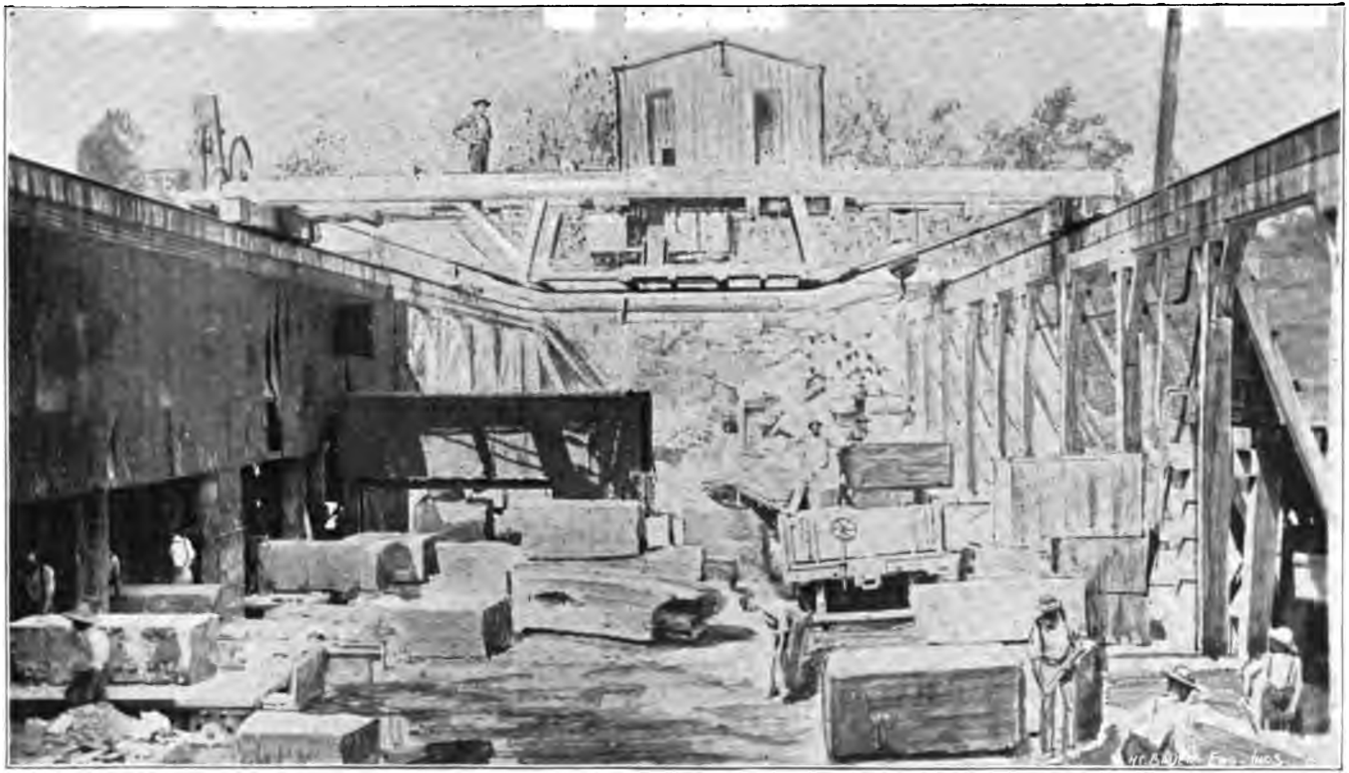
* Made by Prof. W. A. Noyes, Rose Polytechnic Institute, Terre Haute.
† Made by Prof. M. A. Howe, Terre Haute.



PORTION OF THE MILL, YARD AND TRAVELERS OF THE ROMONA OOLITIC STONE COMPANY.

surface. Its chief advantage over the common band-saw is in trimming or dressing blocks; where the stone is to be sawed in slabs, ten inches or less in thickness, the band-saw is used.

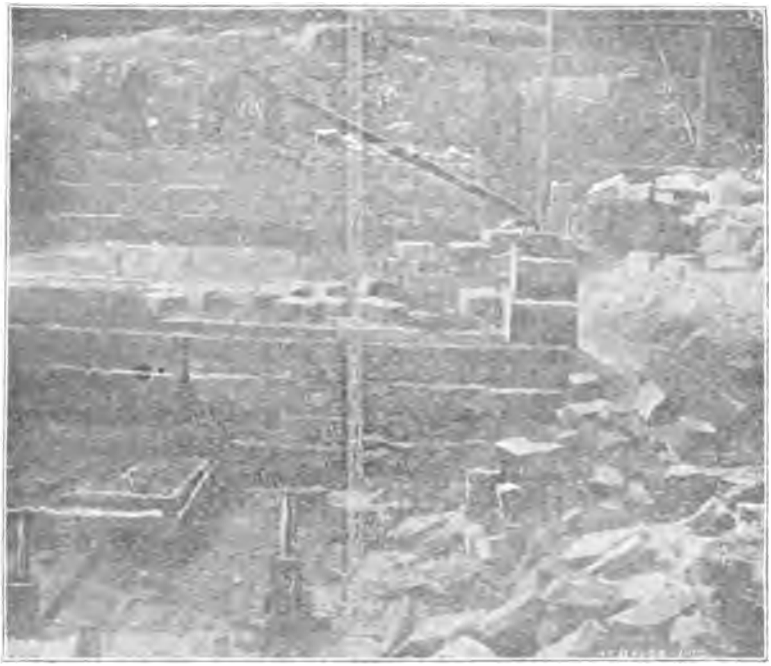


Fig. 11.—Center view looking west in the quarry of the Romona Oölitic Stone Company Romona, Ind.

The company states that for cutting into slabs less than 10 inches thick the band saw is possibly a little cheaper, but where the stone is cut a foot or more in thickness the diamond saw is cheaper, hence the advantage of having one in a large mill along with the gang saws. The machine is very expensive, and the expense in keeping it running is in replacing the teeth that wear out and drop out. By close watch and occasional turning, the teeth may be made to do good work longer than they otherwise would. It would seem that the chief advantage of a saw of this kind is in cutting or trimming large slabs or blocks, and that the work could be more economically done in a large mill by having one for this use, while the slabbing is done by band-saws.

In a Connecticut mill, where a similar saw is used, it is called a stone-cutter, in distinction from the band-saw or slabber. It leaves a surface nearly as smooth as a sand-rubbed face.

The stone from this quarry is nearly all used for bridges and heavy masonry, a comparatively small percentage of it being used in buildings.

As it does not have quite so fine a texture, it will not take such fine carving nor give as smooth a surface as the finer grained stone. It makes as strong and durable a stone as the other, and when the fashion changes will look as well in rock face or tooled surface for building purposes. It would look well in combination with the finer grained stone, by using the coarser grained for facing and the finer for trimming.

The Lilly quarry.—The Lilly quarry, which lies just across the narrow valley about 250 yards northeast of the Romona quarry, was opened by the Oölitic Quarry Company in 1890 and the mill was added in 1892. It has not been in operation during the past year, but the mill and most of the machinery remain, and it may be again operated on the revival of business.

It has switch connection with the Indianapolis & Vincennes Railroad, over which the stone has been shipped. The quarry is less favorably located than the Romona quarry, across the hollow. It is much lower than the railroad, which crosses the valley on a high trestle, and the company has been at the expense of constructing a long branch running through under the railroad and making switch connection with the road about a quarter of a mile further east on the south side.

The thickness of workable stone is less and the stripping greater than in the other quarry. The present quarry face shows (1) a thickness of nearly 10 feet of sand and soil, partly glacial deposit; (2) eight to ten feet of hard, compact, thinly stratified, shelly limestone; (3) 15 to 18 feet of light colored hard oölitic limestone, with numerous toe-nail seams, some on each channel cut; evidently the greater part if not all of this part of the bed has been waste material; (4) five or six feet of compact argillaceous limestone; (5) 20 to 30 feet of oölitic stone, the commercial part of the bed. There is a conspicuous stylolitic seam at the top of the oölitic stone, separating it from the overlying argillaceous limestone. There was only one horizontal seam observed in the face of the quarry stone, and that is an open seam near the middle of the face. There are very few vertical seams, and these not running to any great depth, so that there is very little waste in the quarry bed itself, the expense being in the heavy stripping.

The stone does not differ greatly in texture from that in the Romona quarry, being comparatively uniform, coarse grained, crystalline and fossiliferous. Both buff and blue stone occur, there being apparently a greater proportion of the blue to the buff than in the Romona quarry. The cross grain nearly all dips to the north. The product for 1894 is said to have been used for curbing and bridge piers, and bridge work altogether in 1895.

The Bienert quarry.—The Bienert quarry, which is a half mile or more southwest of the Romona station and a hundred yards west of the railway (the Indianapolis & Vincennes Railroad), with which it has switch connection, was opened by the White River Stone and Lime Company (Simpson & Archer) in 1870. A limekiln was erected and both lime and dimension stone were furnished for a number of years; a rock crusher was added later, but the business has not flourished for several years, and was sold last year (1896) at Sheriff's sale to the Keever Stone Company, of Columbus, O., who have begun active operations.

The limekiln was not in operation in the early part of the year, but was later in the summer.

With a good quality of dimension stone, and the limekiln and rock crusher to use all the waste stone and stripping, the business ought to be profitable.

The crushed stone has been used partly for railway ballast and partly for pikes and is said to have been shipped in considerable quantities. If this crushed stone and lime have paid for their removal it has been a profitable undertaking, as the top stone has by this means been removed over an area of an acre or more, leaving the oölitic stone bare for channeling. Dimension stone has been removed from part of the area, having been channeled three cuts deep about 21 feet. There is a stylolitic (toe-nail) seam through the upper cut, the other two being free from such seams. There are a very few vertical seams.

This part of the stone that has been quarried appears to correspond to the overlying stone in the upper Romona quarries that has been thrown in the waste almost entirely there. If this is the case the bed corresponding to the quarry bed at the upper quarry has not been touched yet at the Bienert quarry. A workman at the quarry stated that a core-drill had been put down, showing three feet of "soapstone," the argillaceous limestone and 25 or 30 feet of good oölitic stone below the bottom of the present quarry floor. If this be the case, there is certainly a large quantity of stone here that can be removed very cheaply.

The Keystone quarry.—Along the I. & V. R. R., about midway between Gosport and Romona, is an old quarry that is said to have been abandoned about six years ago, and is known as the Keystone Quarry. The stone is not oölitic and appears to underlie the oölitic stone, as farther down the railway the oölitic stone is observed with a southwest dip which, if continuous, would bring it some distance above the horizon of the stone in the Keystone Quarry. It is not known to the writer for what the stone was used or how many years the quarry was operated.

The Old State House quarry.—About two and a half miles east of Spencer, on the Denkewalter place, is an old quarry known as the State House Quarry, as it furnished a considerable part of the stone for the State House in Indianapolis; most of the basement story of the State House is said to have come from this quarry. When the quarry was in operation there was a branch railway to the I. & V. R. R. on the north side of White River. An ice jam one spring, about 12 years ago, tore away the bridge crossing White River and it was not rebuilt (it is said to have been built temporarily to remove the machinery), and the quarry was abandoned.

The quarry is on the south side of a small creek from the southeast. The opening covers an area of about 25x50 yards, 35 to 40 feet deep, having in some places six channel cuts, in some places only two. The bottom of the quarry is covered with water so that the character of the stone is not discernible. Above the water there are four stylolite (toe-nail) seams. There are several joint seams running east and west, but no north–south ones were observed.

The stone in many respects resembles that in the Romona quarries, but is more cross-grained and quite hard on the exposed surface. Much of the stone is conspicuously cross-grained, the false bedding dipping west 25° at the bottom of the quarry and east at the top of the quarry. All the exposed faces are much darker than the fresh stone, but none of the quarry faces are disintegrating.

There is a layer of compact, smooth-grained limestone overlying the oölitic limestone having a maximum thickness of about 10 feet, overlain in turn by one to two feet of soil.

There are some bold outcrops of the oölitic stone along the creek at and near the quarry, some perpendicular and overhanging bluffs 30 to 40 feet high; the stone in some places massive, in some places stratified, frequently shelly and exfoliating for a few feet above the water.

While there is much good stone at this locality, there would necessarily be much waste in quarrying it, and the present prices of stone and the active competition there is in the trade would not justify the expenditure necessary to rebuild the bridge across the White River.

STINESVILLE—BIG CREEK DISTRICT.

Oölitic limestone has been quarried in varying quantities at Stinesville and vicinity for many years. There are different quarries in the vicinity, but only two were in active operation during the year 1896, and one of them closed late in the summer.

The stone in nearly all the quarries is of good quality, and large quantities of first-class building stone have been shipped from this vicinity; but in nearly all the openings the stone has weathered deeply, causing much waste in the quarries. The exceedingly low price of stone and the active competition in the trade have placed these quarries at a disadvantage with others having less waste and a greater thickness of stone. Many of the quarries that are now idle will, no doubt, reopen when the stone trade revives, as the stone is of good quality when selected with care.

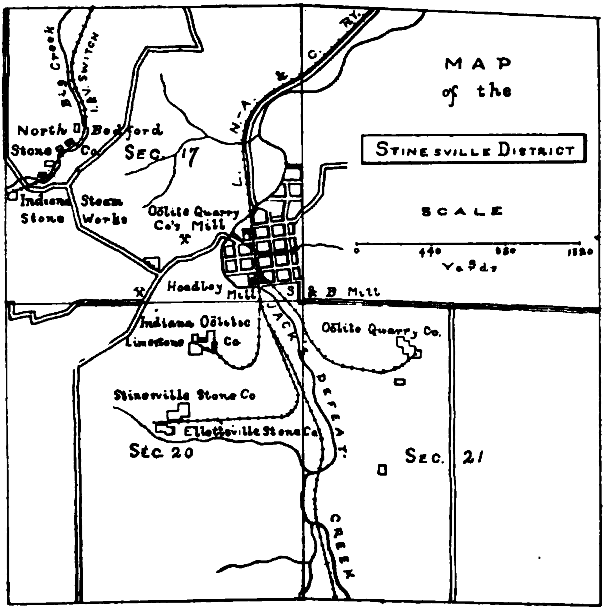


Fig. 15.—Showing the location of the quarries in the vicinity of Stinesville.

Probably the first to open a quarry in the neighborhood of Stinesville was Richard Gilbert, who in 1827-8 quarried oölitic stone on the east bluff of Jack's Defeat Creek, about three-quarters of a mile south of that town. Others followed his example and many small openings were made. From such quarries as these came the stone for the piers and abutments of the bridges over White River at Gosport and the lower bridge over Bean Blossom Creek.

Though enjoying an excellent reputation at home, for many years after the opening of the first quarries the oölitic limestone was comparatively unknown outside the counties in which it occurs.

But with the completion of the New Albany & Salem Railroad (now L., N. A. & C. R. R.), in 1854, the stone assumed commercial importance. On the 31st of December, 1853, Edward M. Watts and William M. Biddle, of Pennsylvania, purchased twenty acres of land on Big Creek about three-quarters of a mile west of Stinesville. On the 26th of June, 1854, they purchased an additional twenty acres adjoining the first purchase. Here, as soon as tools and machinery could be shipped from Pittsburgh, they opened a quarry and prepared to do business on what was then considered a large scale. A substantial steam stone mill of six gangs, rocker-shaft pattern, was erected, and in 1855 they were prepared to furnish both rough and sawed stone to the trade.

The stone was blasted from the ledge in large blocks; these blocks were loaded on heavy wagons, or swung under others which had rear wheels of twelve feet diameter, and hauled by three ox teams to the mill. When cut into the desired dimensions they were loaded on the wagons again and hauled a mile over a rough road to Stinesville to the New Albany & Salem Railroad. The stone was marketed under the name of White River Stone and enjoyed a good sale, principally in Louisville, New Albany and Jeffersonville. But their methods were crude and the work slow. It is said that a single shot broke off from an overhanging ledge enough rough stone to supply the mill two years. The heavy expense attendant on shipping the stone ate up the profits, so work languished and the quarry was finally abandoned in 1868. Biddle and Watts did not give the business their personal attention, but operations were in charge of John Matthews, an English quarryman, who had lately come from the Dean Marble Quarry, near Madison, Ind., then the most noted quarry in the State. During its later years the Biddle & Watts quarry was in charge of Captain John Love, one of the firm.

The Chicago and Stinesville Stone Company was organized in 1889, but the name was later changed to the Big Creek Stone Company by order of the Court. This company purchased the Captain Love quarry and land, the machinery having been previously sold, and constructed a switch five miles long to the I. & V. R. R., joining it two miles west of Gosport. A steam mill with two saw gangs was erected about 75 yards down the creek from the site of the old Biddle & Watts mill. A good business was done by the new company until August, 1893, when the cancellation of orders, which succeeded the financial panic, forced the company to close down and go into the hands of a receiver. The company was reorganized in February, 1895, under the title, "*Indiana Steam Stone Works.*" The new company made a new opening opposite the site of the old Biddle & Watts quarry. The work of exploitation was carried forward rapidly and quite a large amount of stone was gotten out that year. Very little has been done the current year, but next year the company expect to remodel the mill, put in four new saw-gangs and operate the quarry to its fullest capacity.

The Big Creek quarry is the one farthest south. It contains the lightest colored stone of any observed in the oölitic region. While the fresh stone is light colored, it becomes even lighter on exposure, as there is a marked percentage of organic matter that evaporates on exposure. The stone has a close, uniform texture, except in a few places where the fossils make it irregular. The greatest defect is the stylolite (crowfeet) seams, which are sufficiently abundant to cause a great deal of waste, some of the black points running to a depth of six inches or more. Not only do the points from the seam extend deep, but the seams are not always parallel, sometimes running up or down a foot or more from the general level. The weathered stone at the top is very fossiliferous, and some layers through the body of the rock contain a great many fossils.

The northernmost opening of the Big Creek quarry, the one near the Big Creek mill, shows a heavy bed of stone of good quality but much weathered. Irregular weathered fissures, a foot to three feet wide, have formed along the vertical seams and a few horizontal seams appear near the base. See figure 2, Plate XXI for view of the face of this quarry. The water in the opening conceals the bottom of the stone, so that the thickness of the bed is not shown. There are six channel cuts extending about 40 feet above the water, which is said to be 16 feet deep, thus giving a total thickness of between 50 and 60 feet. In the bottom layer exposed, the sixth from the top, is a layer of laminated clayey limestone, five or six feet thick. The stone immediately overlying this compact stone is very fossiliferous, containing large brachiopods and cephalopods. The part immediately underlying the clayey layer appears more compact and composed largely of bryozoa.

There are no stylolitic (crowfeet) seams except near the top, where there are two about a foot apart, the greatest waste being along the vertical seams.

Below is given the results of chemical and physical tests made of samples of the stone from Big Creek quarries, furnished by the Indiana Steam Stone Works.

ANALYSIS OF OÖLITIC LIMESTONE FROM BIG CREEK QUARRIES.

Analysis based upon material dried at 100° Centigrade.

	No. 1. Per Cent.	No. 2. Per Cent.
Calcium oxide, CaO	52.53	52.12
Magnesium oxide, MgO	2.10	2.21
Ferric oxide, Fe_2O_3	0.64	0.71
Silica, SiO_2	0.15	0.50
Carbon dioxide, CO_2	43.49	43.27
Water, alkalies, etc., traces, not determined	1.09	1.19
	100.00	100.00

L. A. Streaker, *Analyst.*
Robt. E. Lyons.

No. 1 is from the interior of the bed, No. 2 from the upper harder layers. The lime in No. 1 is equivalent to 93.80 per cent., lime carbonate in No. 2 to 93.07 per cent.

CRUSHING TESTS OF OÖLITIC LIMESTONE FROM THE BIG CREEK QUARRIES.

No. 1. 6,600 lbs. per square inch, broke with two fair pyramids.

No. 2. 4,100 lbs. per square inch, specimen imperfect, faces not parallel.

No. 3. 6,200 lbs. per square inch, specimen imperfect, faces not parallel.

No. 4. 2,800 lbs. per square inch, specimen imperfect, faces not parallel, split off on one side, crushed on edge.

Absorption 1-17 or 5.75 per cent. (For fire tests see page 317.)

The North Bedford Stone Company was organized in 1889 and opened a quarry on Big Creek, about a quarter of a mile north of the *Indiana Steam Stone Works*, on the Big Creek branch of the I. & V. R. R. A substantial mill was erected, with five gangs of saws, and a good business was done until the panic of 1893, when the Company went into the hands of a receiver, Hon. Smiley Chambers, of Indianapolis, acting in that capacity.

At the mill of the North Bedford Company is an opening where a small quantity of stone has been removed. The character of the stone is similar to that in the next larger opening north of the mill, except that it has weathered much deeper.

In the opening north of the mill, the most eastern or northern one on Big Creek, the stone is overlain by a heavy bed of glacial material, 21 to 25 feet, the bottom of which consists of a dove-colored clay, containing many pipes of iron ore, the upper part composed of sand and pebbles. The oölitic stone is dark gray and buff to yellow in color, with some cross-bedding. Some layers are fossiliferous, containing large fossils, which, in places, have leached out, giving the stone a cavernous or pitted appearance. The bottom of the opening is concealed by water, and the total thickness of the bed cannot be seen from the opening.

All of the quarries on Big Creek are on a branch from the Indianapolis & Vincennes R. R., which crosses White River and connects with the main line a short distance below Gosport. While much good stone has been removed from the quarries and much remains, there is much more waste stone to be handled than in other more favored localities.

The Terre Haute quarry.—Cosner & Davis, about 1880, opened a quarry north of the forks of the county road, a half a mile west of Stinesville, and later sold it to Lyne, Chadwick and others comprising the *Terre Haute Stone Works Co.*, who operated it in connection with a mill in Terre Haute. A large amount of stone was taken out here, all of which had to be hauled to the railway. An attempt to put in a switch connection with the L., N. A. & C. R. R. resulted in litigation, and before it was decided in their favor the company concluded to open up at the present site of the Terre Haute Quarry, one-half mile southeast of Stinesville. Switch connection was made with the L., N. A. & C., and a mill built at Stinesville. Both quarries and mill were purchased in 1892 by William Lilly & Co., operating under the title of *Oölitic Quarry Co.*, the same company owning one of the quarries at Romona. In the quarry southeast of Stinesville the stone varies in different parts of the opening from two to four channel cuts deep (13 to 25 feet). It is overlain on the east side by from two to three feet of compact limestone, but elsewhere is overlain by soil only, and the upper surface is weathered very unevenly. There are a few crowfeet seams and a number of vertical ones, the east-west ones being most numerous. There is considerable cross-bedding in places on the quarry face, and while there is considerable waste in working this quarry, there has been a great deal of good stone quarried.

The opening in the old Terre Haute quarry, about half a mile west of town, is about 120 x 250 feet and 25 to 30 feet deep. There is no switch to the quarry, and the stone was hauled by oxen to Stinesville and loaded for shipment. There are numerous east-west seams, but no north-south ones were observed. The north face of the quarry is a joint seam, which, while regular in its general direction, has a much roughened surface, much ridged and marked, showing considerable cross-grain and lack of uniformity (see No. 3, in plate XX). The texture for the most part is coarse and fossiliferous. The bryozoa predominate among the fossils, but there are many gastropods, brachiopods and a few trilobites. The fossils are abundant throughout all the rock examined, but in a few places the larger forms are segregated more than elsewhere. While this stone would make a fairly good and durable building stone, it is not adapted to carved work or smooth dressing, and is not the kind most in demand at present.

Other quarries were opened up about the Old Terre Haute quarry, though none of them had railway connection and consequently did little quarrying. Limekilns were operated in connection with some of these, but lime made from the oölitic limestone, while white and pure, did not, apparently, find a ready market.

The Griswold quarry.—One of the largest and best equipped quarries in the district is that known as the Griswold quarry, located about a quarter of a mile southwest of the Stinesville station on the Monon railway. There is a switch connection from the quarry to the railway. There are two mills at the quarry, equipped with saws, planes, steam travelers and a good supply of quarry machinery. The quarry was opened in 1880 by Charles Eppinghausen, and purchased in 1890 by the Indiana Oölitic Limestone Company, who put in a new mill and new machinery. The quarry was idle the latter part of the summer of 1896, the first time, it is said, since it opened in 1880.

The thickness of the stone quarried is about 35 to 40 feet, and it is overlain by four to six feet of compact limestone, which had weathered away over part of the area quarried, and which does not appear in the quarries a quarter of a mile farther south. There is a thickness of two to three feet of overlying soil. The stone has been removed six channel cuts deep, but the oölitic stone extends still deeper. There are several open weathered joint seams filled with residual material. These are all on the east-west system of joints, none of the north-south ones showing on the quarry walls. There are a few stylolitic (toe-nail) seams, but they are not numerous or large.

The stone has a medium fine grain and buff color, and shows considerable cross-grain in places, which does not appear to be greatly pronounced, nowhere showing a cleavage or ready parting on the cross-bedding.

The supply of good stone here is almost unlimited, and under any ordinary conditions of trade it ought to be quarried with profit.

Stinesville Stone Company quarry.—The quarry of the Stinesville Stone Company (Malone & Pickel) is about a quarter of a mile west of south of the Griswold quarry. The quarry was opened in 1889 by the Stinesville and Bloomington Stone Company, composed of James Williams and others, and sold to the Stinesville Stone Company in 1895. They are working six—and in some places seven—channel cuts of stone. The upper part of the bed is much weathered and the upper cut—in some places the two upper cuts—largely waste. The total thickness of the bed is about 40 feet, including 30 feet of good stone.

There are a number of vertical seams, both east-west and north-south ones. There are very few crow-feet or horizontal seams. One layer three feet from the top is called the "gloss" layer, said to have a gloss like silk. Much of the stone is cross-grained, particularly in the upper part of the bed. There is no blue stone. While it is all buff it is a little darker in the botton of the quarry than in the top.

The company has no mill at the quarry, but saws its stone at the mill of the Stinesville & Bloomington Co., or at their own mill at St. Louis. They utilize nearly all the waste from the quarry by shipping it to the Illinois Steel Co., Chicago, for use as furnace flux. It is the only quarry that was in operation at Stinesville in August, 1896.

The Ellettsville quarry, which adjoins the one above on the south, is a smaller opening, first operated in 1891, but not in operation in the summer of 1896. The stone is similar in character to that in the other quarry. At the east end of the opening it is weathered deeply, much of the upper cuts being waste. At the northwest end there are fewer seams and a greater percentage of clean solid stone. The stone is nearly all buff but there is a faint bluish tint at the base.

The Dunn Stone and Marble Co., the Monon Limestone Co., and the Stinesville Oölitic Stone Co., have holdings of stone land in this vicinity, but as yet no quarries have been opened by them.

ELLETTSVILLE DISTRICT.

In 1862, John Matthews opened a quarry one mile north of Ellettsville. Two years thereafter he began the erection of a mill and pushed the business with great energy. From the first the firm of John Matthews

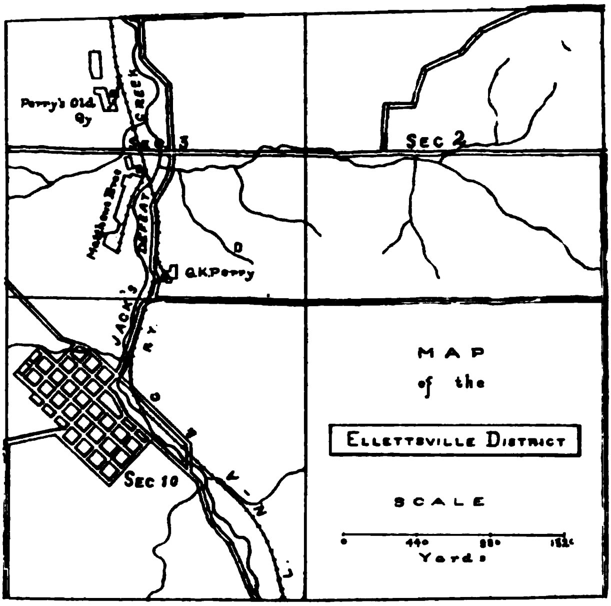


Fig. 16.—Showing the location of the quarries near Ellettsville.

& Sons realized a good profit from their business. The introduction of steam channeling machines and steam hoists gave a new impetus to the stone industry. The first channeling machine operated in the oölitic stone belt was a Wardwell, purchased by John Matthews & Sons about 1877, at a cost of $6,000, four times the manufacturer's price to-day. This machine is still in use at this quarry. After the death of John Matthews the firm name was changed to Matthews Bros., and under the direction of Mr. Fred Matthews the works are still in active operation.

John Kostenbader & Co., in 1864, opened a quarry about half a mile north of the Matthews quarry. This quarry was worked out and abandoned sometime in the seventies.

In the spring of 1866, Maj. H. F. Perry opened a quarry between the Matthews and Kostenbader quarries. The machinery of the Biddle & Watts mill was transported here and set up. The old engine, which before its service with Biddle & Watts had done duty on an Ohio River steamboat, might have been seen in operation as late as 1895. A few years after the opening of the quarry Captain G. K. Perry became a member of the firm of *Perry Bros.* Later the quarry was worked out and abandoned and a new one opened east of the railway and but half a mile north of town. A new mill was erected here, though the old one is still in operation. In 1895 H. F. Perry retired from the business, leaving G. K. Perry sole proprietor.

In 1869 *Sharp & Hight* opened a quarry a little south of the Matthews quarry, but at the death of the owners, which occurred a few years afterward, the plant was sold to the Matthews. In 1896 Captain Perry opened another quarry in the field about a quarter of a mile northeast of his lower mill.

In 1872 *John Matthews & Sons* and *C. F. Kelly & Perry Bros.* opened quarries on the west side of the L., N. A. & C. Railroad, about midway between Ellettsville and Stinesville, but after three years' operation it was found that they could not be profitably worked on account of the number of dry seams and joint cracks, so they were abandoned. The Cornelius quarry, on an adjoining tract, operated during the same time, suffered a like fate for similar reasons.

There are two companies operating quarries at Ellettsville, one since 1862 and one since 1866. These quarries, which have been in continuous operation for thirty years or more, have furnished a great deal of excellent oölitic limestone to many widely separated points. The quality of the stone in these quarries is fully up to the average for the whole district, yet, as at other points, the stone is not all first-class by any means. The stripping is not excessive, yet in some places heavy enough to be burdensome; there are a number of crowfoot seams and in several places coarsely fossiliferous areas and some cross bedding, all combined with the fact that the bed is not heavy, are sufficient to show that careful business methods are necessary to successfully compete with other points. Each company has well-equipped mills and is supplied with good quarry machinery.

The quarry opening at Perry's upper mill, operated for many years, appears to be at least temporarily abandoned by Mr. Perry, who has started a new opening in the field about a quarter of a mile north of east of the upper mill. At the new opening the core drill is said to have shown thirty-two feet of uniform buff oölitic stone. The stone that has been removed, but one channel cut (six feet) deep, July 2, 1896, is a fossiliferous buff stone, fairly uniform in texture, being a little coarse in places. There is one stylolite (crowfoot) seam and several vertical ones, and the stone is considerably weathered along the vertical seams, which are quite open in places.

The opening at the mill has several interesting scientific features. It shows considerable cross-bedding, which runs in different directions, and shows the contact between the oölitic stone and the overlying compact (Mitchell) limestone, which in most places is quite regular but here follows a quite irregular jagged line (see Plate XXI, No. 6). The south end of the quarry shows a rather curious intermingling of the buff and blue stone. The quarry is about 100 yards long and 40 to 50 yards wide. It is four channel cuts (about 25 feet) deep at the middle and north end and three cuts at the south end. Part of the stone has a remarkably fine grain, possibly not surpassed anywhere in the belt, but it is not uniform throughout the quarry, as in some places it is coarsely fossiliferous.

The opening at Perry's lower mill, a mile and a quarter north of Ellettsville, on the west side of the railroad, has not been worked for a number of years. It covers an area about 50x125 yards, four to five cuts (25 to 30 feet) deep. It is overlain by 10 to 12 feet of laminated compact limestone, which lies on the oölitic quite conformably in contrast with that at the upper mill. There are numerous vertical east-west joint seams and one or two crowfoot seams.

In an old abandoned opening, about 200 yards north of the quarry at the mill there is a local change in the face of the quarry. Apparently the compact limestone that overlies the oölitic stone elsewhere, here appears in the face of the quarry with good oölitic stone overlying it. A section of the quarry face shows eight feet of semi-oölitic stone, two to six inches of hard compact limestone, four to six feet of good oölitic stone, two to four feet of compact earthy limestone, and ten or more feet of good oölitic stone.

Matthews Bros. quarry.—The Matthews Bros. quarry is on the west side of the railroad and the valley, and between G. K. Perry's upper and lower mills. The quarry extends along the creek bluff for more than a quarter of a mile, and is worked back into the bluff until the thickness of the stripping prevents further work with profit. As might be expected, along a face of this length there would be some variety in the stone. At the north end in places the rock is coarsely fossiliferous, containing many well preserved specimens of cephalopods and gastropods. At the extreme south end the rock exfoliates along the exposed channel face to some extent, that is—it flakes or peels off parallel with the surface, due to the freezing of the moist stone. In places near the middle of the quarry the stone is almost entirely made up of the oölitic or rounded particles.

The east west vertical seams occur at intervals of 20 to 40 feet along the face. There are very few cross-seams. Several stylolitic (crowfeet) seams occur, but they are not numerous. In some places there are segregations of iron oxide and organic matter along these seams.

Most of the stone is buff in color, yet both buff and blue are obtained, in some places intricately intermixed.

The company has a large mill, and has furnished a great deal of good building stone to the market during the many years they have been in business here.

Matthews Bros. have made a small quarry opening on the hill east of the railroad, about a quarter of a mile east of Perry's upper mill. No railway connection has been made to the opening, and it is not now in operation. The rock is coarsely fossiliferous in places, and contains numerous seams, both vertical ones and stylolite (crowfoot) seams. Many of the stylolitic points along the seam are capped with fossils, most commonly cup-coral (*Zaphrentis*).

Near the middle of section 7, two miles east of Matthews Bros.' mill, is one of the thickest beds of oölitic stone anywhere observed in the oölitic region, so far as can be judged by the outcrop and depending on the accuracy of the aneroid barometer, which makes the thickness of the oölitic stone at this point 100 feet. It is not uniform from top to bottom, and part of the bed is concealed by soil, but most of that exposed is of a quite fine grain and all buff on the outcrop.

BLOOMINGTON—HUNTER VALLEY DISTRICT.

Possibly the first use of oölitic stone in Monroe County was in the county court-house, which was begun in 1819. The body of the building is of brick, but the foundation, window sills and lintels are of oölitic stone. John Ketchum, the contractor, quarried the stone on the Ketchum farm, hauled it eight miles over oölitic stone and erected it upon oölitic stone of as good quality as the kind chosen. The quality of the stone selected speaks for itself, as it stands in the court-house after an exposure of nearly eighty years.

As early as 1856 stone was sawed by hand, in Bloomington, by one Jesse Carson (or DeCourey), and some of his work can still be seen in old buildings and in monuments in the cemetery west of the city. But the stone business in this locality did not assume any commercial importance until the development in 1891 of the quarries in what is known as the Hunter District, one and a half miles northwest of the city.

The Morton C. Hunter Stone Company, organized in Bloomington, made a careful examination of the stone in Hunter Valley by core drilling, and, having satisfied themselves that it existed in vast quantities, and that its quality would meet all the requirements of builders, proceeded at once to put in a branch, more than a mile in length, from the L., N. A. & C. Railway to this tract, and to put machinery to work quarrying the outcrop. A substantial mill was erected. The stone found a ready market, and the success of the Hunter Company led others to venture into the same field.

The *Chicago and Bloomington Stone Company* was the first to follow the Hunter Company, opening in 1892 what is known as the Johnson Quarry, a short distance northeast of the Hunter quarry. The quarry is operated in connection with mills in Chicago by its owners, who are cut-stone contractors.

The *Norton Stone Company* was the next in the Hunter district. In 1892 a quarry was opened and a mill built southeast of and just across the valley from the Hunter quarry. In March, 1895, the Norton quarry was purchased by the *Consolidated Stone Company*, becoming "Consolidated No. 1" of their series of quarries.

In December, 1896, the Consolidated acquired the Hunter quarry which they had been operating for some time under lease. It is known as "Consolidated No. 2."

Perry, Matthews & Perring followed in 1893 by opening the Crescent quarry, a half mile east of the Hunter. The *Star Stone Company* in 1895 opened the Star quarry, a half mile north of the Crescent quarry. *Hunter Bros.'* quarry, just west of the Star, followed in 1895, and in the same year the *Hunter Valley Stone Company* opened a quarry alongside of the Crescent. In 1889 the Bloomington Oölitic Stone Company opened a quarry in the southwest part of the city of Bloomington. After a few years' operation it was found unprofitable, partly because of the hardness of the stone and partly because of the expense of getting rid of the spalls and other waste. The quarry was abandoned in 1893. In 1895 the property was purchased by the Henley Stone Company as a site for a stone sawmill, which they proceeded to erect, and which has been running steadily ever since.

The *Central Oölitic Stone Company* was organized in 1890. The next year a quarry was opened and a mill erected on their property in the northern part of Bloomington. The quarry was abandoned after a year or two, but the mill is still in operation.

Thus, including the two mills in Bloomington, there are seven active quarries and four mills in the district, besides several small abandoned quarries.

The good stone through Hunter Valley is 25 to 40 feet in thickness, from three to five channel cuts in the different quarries. It varies in character, both in grain and color. Both fine-grained and coarse-grained stone occurs, and both blue and buff colors. The stripping is light at all the quarries, very light compared with that in many other localities. Although one of the newest, it is, at the same time, one of the most productive districts in the State. During the summer of 1896, when so many quarries were closed, all the quarries in the valley were in operation except one.

A branch railway, known as the Hunter Switch, connects all these quarries with the Monon Railway, a little more than a mile distant.

The *Consolidated Quarry No. 1* (Norton) is the one furthest south in the valley, and on the east side. It is about 150 yards long and 30 feet deep. The stone is covered with a loose, brown, sandy clay two to four feet thick, and in most places there is a thickness of one to six feet of the upper part of the bed much weathered, often into loose fragments in the residual soil. There are a few vertical seams, but only one bedding seam was observed. The grain is tolerably fine and uniform, with few large fossils. The slope above the quarry is very gentle, so that twenty acres or more of stone are available here with but little more stripping than that on the present face.

The Hunter Quarry (Consolidated No. 2) is on the west side of the valley about 200 yards northwest of No. 1. The stone is very similar to that in No. 1, and the quarry is about the same size There is considerable mixed buff and blue stone, as the line of parting between the two colors is very irregular. The bottom of the bed is blue, and the buff averages from ten to fifteen feet of the top of the bed, but in some places the line of parting may be twenty feet from the top, and in one place the buff extends to the bottom of the quarry. At the south end of the quarry the upper part of the bed contains many small calcite veins—"glass seams"—which interfere somewhat with the working of the stone where they occur. In a few places the stone is decidedly oölitic, made up almost wholly of rounded particles. Much good stone has been shipped from these two quarries in the past few years.

The Johnson Quarry, operated by the Chicago and Bloomington Stone Company is the next one north of the Hunter quarry and on the opposite or east side of the valley. The stone is similar in character to that above, but has not been quarried so deep—three and four channel cuts. The opening is not quite so large as the ones above, but a large additional area has been stripped ready for quarrying, showing a comparatively even surface beneath the soil covering on which the channeler can begin with little expense. (See Plate XXI, No. 3.)

The Hunter Valley Quarry is in a tributary ravine a quarter of a mile east of Consolidated No. 2 (Hunter) quarry. It is one of the newer quarries of the district, having been in operation only a year or two. The entire thickness is not shown in the opening, which at present is about 20 feet deep in the buff stone. The upper part of the bed is much corrugated and weathered very irregularly, in marked contrast with the Johnson quarry, less than a quarter of a mile to the northwest, where the surface beneath the soil is comparatively level. Compare Figs. 1 and 2 on Plate XXI.

The Crescent Quarry, which lies just south of the Hunter Valley quarry, is an older, larger quarry, having two openings, one of which is about 100 yards long, 30 yards wide and six channel cuts 35 to 40 feet deep. The stone is buff near the top, with a blue-gray tint at the bottom of the opening. It has a medium coarse fossiliferous texture, which in a few places is quite porous from the casts of fossils which have leached out. There are a few vertical seams, and the upper two to three feet of the rock is weathered, loose and shelly, but the line of parting between the shelly stone and the sound stone appears to be quite regular. There is a thickness of two to four feet of sandy clay overlying the oölitic stone.

The Hunter Bros. Quarry is in a small tributary ravine less than a quarter of a mile northeast of the Johnson quarry. The quarry was not in operation in 1896, the hole being partly filled with water. Four channel cuts (about 25 feet) are exposed and there is not less than one,

1. VIEW LOOKING SOUTH IN THE STAR QUARRY.

2. CONSOLIDATED STONE CO., QUARRY No. 4, DARK HOLLOW.

probably two, covered with water. The upper part of the bed is buff, which extends down into the third channel cut from the top. The lower part of the bed is blue. There are a very few vertical seams, but no stylolitic (crowfeet) seams were observed. The stone is medium coarse-grained and comparatively uniform in texture.

The chemical analysis of the stone from this quarry shows a remarkably pure carbonate of lime.

CHEMICAL ANALYSIS OF OÖLITIC LIMESTONE FROM HUNTER BROS.' QUARRY.

	PER CENT.
Lime carbonate ($CaCO_3$)	98.11
Magnesia carbonate ($MgCO_3$)	.92
Iron and alumina ($Fe_2O_3+Al_2O_3$)	.16
Insoluble residue	.86
Total	100.05
Specific gravity	2.46
Absorption of water in 24 hours	5.18

The crushing tests show a freestone of great uniformity.

		LBS PER SQ. IN.	
No. 1.	On natural bed	5,900	2 fair pyramids.
No. 2.	On natural bed	6,900	2 good pyramids.
No. 3.	On natural bed	4,400	one side split off.
No. 4.	On edge	4,200	one side split off.
	Average of the four	5,350	
	Average of the first two	6,400	

As specimens three and four did not have parallel sides, the last figure, 6,400, is the fairer average of the strength of the stone. It stood the fire tests as well as any of the specimens tested. (See page 317.)

The Star Quarry is almost 100 yards southeast of the Hunter Bros. quarry. It shows a fine body of stone similar to that in the adjoining quarry. The opening is about 100 yards long by 25 or 30 yards wide and 40 feet deep at the deepest point, having six channel cuts of stone. The stone is nearly all blue, but there is a little buff on the top at the east end, which contains some "bastard limestone," an impure very hard form. See Plate XXIX, which shows a picture of this quarry.

If one might judge from the character of the stone in the quarries open, and the appearance of the outcrops of oölitic limestone in the Hunter Valley, the prediction might well be made that the stone industry will greatly increase and the production here be much more than in the past. There are several features in regard to its occurrence that favor its removal with profit. The stripping is comparatively light, the stone is not so deeply or badly weathered as in many other localities. There is a fair thickness of stone. There are not many seams, either vertical or horizontal, and not many large fossils. A considerable portion of the stone is blue, and as the market demand at present is for the buff, that may be against its more rapid development, but it is only a question of time, possibly a short time, until the demand for the blue will again increase.

There are several quarry openings in and near the city of Bloomington, but all have been abandoned. There is an old quarry one or two blocks east of the Indiana University Campus, apparently in strata underlying the oölitic. The stone outcrops also on the University Campus. There is a small quarry about half a mile southeast of the University, another in the town on Second street, about a quarter of a mile north of east of the old University building, another at the Henley mill, a quarter of a mile west of the depot, one at the Central mill along the Monon Railway in the north part of town, and two or three small quarries west of the Monon and south of the town, between the Bloomington and McDoel stations, but they have apparently all been abandoned permanently, and a description is not necessary. Considerable stone in the aggregate has been taken from all of them combined, but no large quantity from any one of them. Good stone could yet be obtained at many of them, but the quantity, quality and cost of quarrying militate against its further development in competition with more favored localities.

THE SANDERS DISTRICT.

The pioneer company in the Sanders district was the *Oölitic Stone Company of Indiana*, which, in 1888, opened a quarry and constructed a branch connecting with the L., N. A. & C. R. R., and costing $10,000. In 1890 David Reed obtained control of the quarry, and it was at once taxed to its utmost to furnish stone for the construction of the Auditorium, Chicago. In 1894 he opened another quarry north of the switch and in 1895 erected a mill.

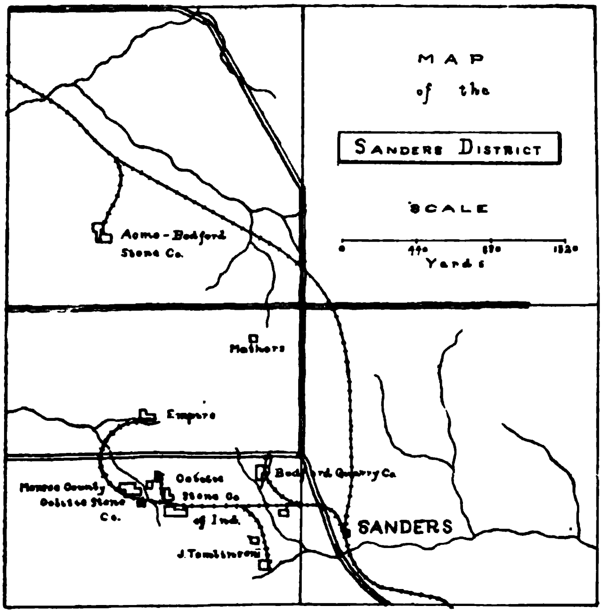


Fig. 17.—Showing location of the quarries in the vicinity of Sanders.

The *Monroe County Oölitic Stone Co.* organized in 1889, opened the Adams quarry, and erected a mill just west of the Reed oölitic quarry.

In 1891 the *Bedford Quarry Co.* opened a quarry east of Reed's Oölitic, which is known as Reed's Bedford. It is now in active operation.

The Empire Stone Co., in 1892, opened a quarry north of the Adams quarry and on an extension of the same switch. The Empire quarry has not been in operation for a year.

In 1892 *John Tomlinson & Son*, of Chicago, opened quarries south of Reed's Bedford quarry. They ran for two years, since which they have been idle.

In 1893 the *Bloomington-Bedford Stone Co.* opened a quarry known as the B. & B. quarry, something over half a mile north of the Empire quarry and near the main line of the L., N. A. & C. R. R. A great amount of money was spent in developing the property, but it proved to be unprofitable and was abandoned. It was leased in 1895 by the *Acme-Bedford Stone Co.* and purchased by them in 1896. They developed the quarry in another direction with most promising results. The quarry is operated in connection with extensive mills in Chicago belonging to the same parties.

The Matthews Stone Company was organized in 1892, but no opening was made until 1895. Their quarry lies about half a mile southeast of the B. & B. quarry. As yet it has no railway connection and has been idle the present year. In fact nothing has been done beyond a little preliminary work.

There are now, as stated, nine quarry openings on the branch railroad at Sanders and two others along the Monon between Sanders and Clear Creek Station, within two miles of Sanders. Six of these were in operation in July, 1896. One, from which apparently no good stone was obtained, is permanently abandoned and four are temporarily idle.

The quarries in operation are Reed's Bedford quarry, in the northeast quarter of the southeast quarter, section 33 (8 north, 1 west); Reed's Oölitic quarry, two openings, northwest quarter of southeast quarter, same section; Adams' quarry, two openings, northeast quarter of southwest quarter, same section, and the Bedford and Bloomington quarry, in the southwest quarter, section 28 (8 north, 1 west). The Tomlinson quarries, two openings, the Empire and Matthews quarry, each one opening, are temporarily idle.

The average thickness of the oölitic alone in the district is about 35 to 40 feet, with a maximum of possibly 50 feet. The workable portion of the stone varies from 12 to 40 feet, depending on the depth to which the weathering influences have extended and the local variations in the texture.

In several of the quarries, noticeably the most southerly ones, there are numerous large, vertical fissures, extending through the limestone, most of them having a general east-west (a little north of east and south of west) course, only a very few north-south ones occurring, and those quite small. These fissures are due to weathering along the joint planes, and vary from a few inches to eight feet or more in width. They are now filled with the residual red clay. As a rule they are widest at the top, but their walls are often quite irregular, as in all cave-like openings. Hence there is a great quantity of waste rock to handle. Some of these open seams extend but two or three feet below the surface, while others run as deep as the stone is quarried—20 feet or more. These fissures are less pronounced, and almost disappear where there is any considerable thickness of overlying rock to protect them from the weathering influences.

Except in the much weathered portion at the top there are few horizontal or bedding seams. There are several stylolite or "toe-nail" bands in three of the quarries, but none were observed in the other quarries. Cross-bedding is shown in several of the quarries, but is not so prominently marked as in some other localities. It is shown in the Adams quarry, the Matthews quarry and the Empire quarry, the latter in some places having a marked cleavage along the false bedding.

The texture varies slightly in the different quarries, and, to some extent, in different parts of the same quarry. However, excepting the few more coarsely fossiliferous layers, the texture is medium coarse and semi-crystalline, with numerous oölitic or rounded grains. It is fully up to the average in resonance, compactness and low porosity. While soft in the green state, it seems even harder than the average, when seasoned. The coarsely fossiliferous bands, as in other localities, frequently are porous from the leaching out of the shells.

The proportions of the buff and blue stone vary greatly in the different quarries, and as the parting between the two colors is very irregular, there is much variegated stone that is remarkably uniform in everything but color. The contrast between the two colors is not striking, yet, unfortunately, it is more pronounced on the exposed channel face than on a fresh fracture. In some of the openings only buff stone is quarried. The distribution of the blue and the buff in the B. & B. quarry is different from that in other places, and apparently contradictory to the commonly accepted theory. It may be one of the exceptions we hear of that it takes to prove the rule. In the first opening on the edge of the outcrop near the surface there was much blue and variegated stone, while in the present deeper opening, higher on the hill, the rock is all buff. In Reed's Bedford quarry, in the Tomlinson quarries and in the Empire quarry both blue and buff occur with very irregular parting, the buff running deepest along the vertical joints, and the blue forming an irregular band along the stylolite seam. (See plate XIX.)

In the larger openings of Reed's oölitic quarry they have channeled to the bottom of the oölitic stone, six channel cuts deep in one place, showing the bottom layers to be very fossiliferous. In the smaller opening the quarry stone is overlain by a dull brown, fine-grained, impure, soft, earthy rock, four to six feet exposed, overlain by three to four feet of sandy clay. The part of the oölite immediately underlying the impure rock covering is in places very coarse-grained, coarsely crystalline, and contains many fossils. (See Plate XIX.)

The blue stone in the Empire quarry in places contains numerous small, rounded, black specks which do not appear in the buff.

The stone in the B. & B. quarry is quite fossiliferous, and in places contains more oölitic or rounded particles than that in the surrounding quarries. The foreman reported that a core drill had been sunk 70 feet without reaching the bottom of the oölitic stone, but that at that depth the rock, while still oölitic, was too hard to be worked with profit, and the drill was stopped.

There is the following machinery in this region, July 3, 1896: 21 channelers, 11 of which are in operation, and one is under water; 11 derricks; five steam drills; eight saw gangs, and eight steam pumps.

The conditions for the economic production of good stone in this (Sanders) district are probably above the average, as the workable stone has a fair thickness and the stripping is not heavy. The greatest waste is that caused by the irregular vertical seams and the intermingling of the buff and blue colors. Large quantities of quarried stone are seasoning at each of the quarries, except the Matthews quarry, which is quite new, and has produced but very little stone so far.

CLEAR CREEK VALLEY BETWEEN CLEAR CREEK STATION AND HARRODSBURG.

Time did not permit a detailed examination of the Clear Creek Valley outside of the quarries in operation, but some of the most promising out crops were hastily examined and the results here noted.

There are probably as many large and promising outcrops of oölitic limestone along this part of Clear Creek Valley as in any other area of equal size in the whole oölitic area. But the only quarry opening that has been made was a failure. There is no doubt that there is a vast quantity of good stone in this region, but it yet remains to be seen how successfully it can be produced in commercial quantities in competition with the other districts. As may be seen on the map, the deposits are removed some distance from the railroad, which is the principal reason why they have remained undeveloped. A new line of road is contemplated down the valley, which, if built, will, no doubt, open up a number of new quarries at once.

It must not be understood that the following are all the good exposures of oölitic stone that there are in the area, or that they are necessarily the best. They are the ones observed by the writer, who was directed to what were said to be the most promising outcrops.

About a mile southwest of Sanders, along a small tributary of Clear Creek from the east, in the northwest quarter of section 4 and the northeast quarter of section 5 (7 north, 1 west), the limestone is exposed along the watercourse and on the slope south of the stream. In section 4 there is a massive ledge of the stone exposed along the stream 8 to 10 feet thick free from seams, of fine grain, slightly crystalline, and slightly cross-grained in a few places. The record of the core-drill* put down at this locality gives:

"Fairly good buff stone	12 feet.
Very fine quality blue stone	30 feet.

One crow-foot 12½ feet from the top. Did not drill through the ledge because of accident to the drill."

A boring in the west half of the northeast quarter of section 5 (7 north, 1 west), a little more than a quarter of a mile west of the above, shows:

"Splendid buff stone	51 feet.
Fairly good blue stone	12 feet.

No crow-feet, flint or dries, or anything detrimental whatever. The stripping will probably be from two to eight feet thick, and mostly soil."

The surface of the stone on the outcrop at this point is nearly all smooth, firm and compact, with rounded corners. It shows rather pronounced cross-grain in two places, and a hundred yards or more further west, at the point of the hill, there is a ledge three to four feet thick of coarsely fossiliferous stone rapidly disintegrating into loose sand, yet the greater part of the stone exposed here is comparatively solid.

On the west side of Clear Creek, in the east half of section 12 (7 north, 2 west), south of Victor Postoffice, there is one of the largest outcrops of the oölitic stone observed anywhere in the State. The massive oölitic stone, 40 to 50 feet thick, forms a bold perpendicular bluff overlooking Clear Creek. From this bluff in places huge bowlders, 20 to 100 feet in diameter, have broken away from the face of the ledge and lie scattered along the base of the bluff. The accompanying illustration (Plate XXX) shows a view of this bluff, the upper part showing a view of the bluff from a little distance, the lower part a nearer view of a portion of the face. Weathering brings out a few vertical seams, but very few, and these, as will be noticed, are remarkably regular, so that even near the bluff where the weathering agencies have penetrated there will be

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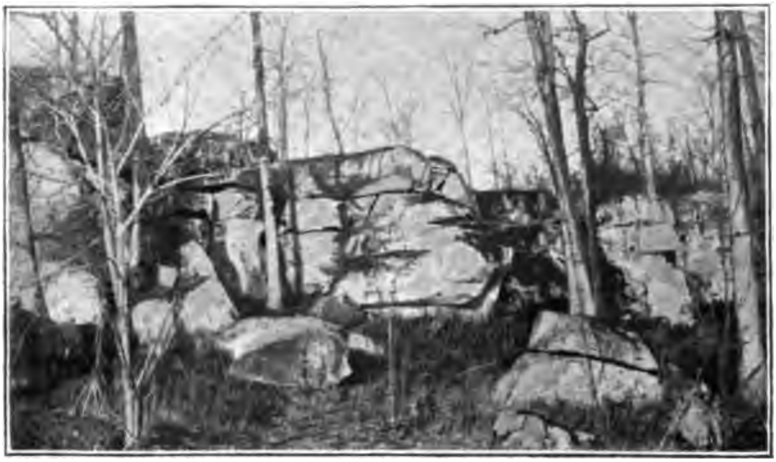
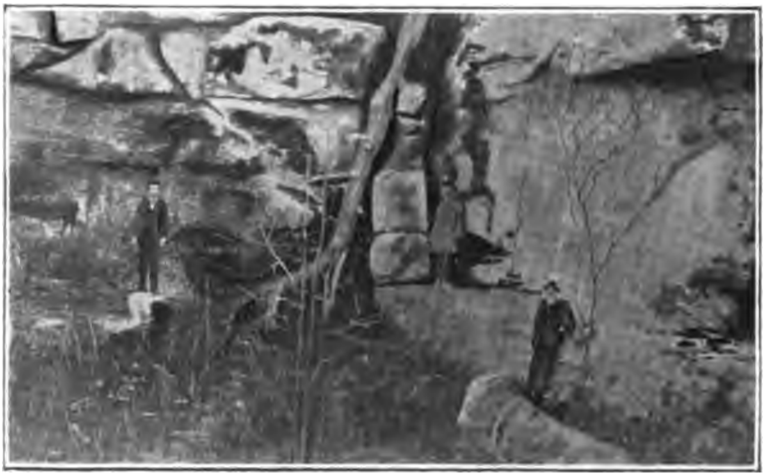
*All of the drill records given in this chapter are copied from the statements made and sworn to by the drillers before a notary public, and by drillers who have worked in different parts of the oölitic region for a number of years.



1. OUTCROP OF OOLITIC LIMESTONE.

On Lot 18 of the Buff and Blue Oolitic Stone Co., on west bluff of Clear Creek, Sec. 12, T. 7 N. R. 2 W.



2. NEARER VIEW OF PORTION OF THE ABOVE BLUFF.

little waste from the seams. The stone is remarkably uniform in grain, color and durability.

The sound stone extends to the top of the bluff, there being no soil at the edge of the bluff, and the slope back of the bluff being a gentle one. An outcrop in the field between this bluff and Victor Postoffice shows a coarsely fossiliferous stone.

In a small ravine, 100 to 200 yards southwest of Victor Postoffice, near the middle of the north half of section 12 (7 north, 2 west), is a large outcrop of oölitic stone, which is very much cross-grained and weathered very unevenly. Most of it is fine grained and light colored.

Along the south side of the branch west from Victor Postoffice, through the northwest quarter of section 12, massive oölitic stone of good quality outcrops in a number of places.

In the southwest quarter of section 2 (7 north, 2 west), on the south side of the branch, is a low bluff of remarkably sound, compact, flawless stone, extending along the watercourse for 200 or 300 yards without a seam. The total thickness of the stone is not shown at this point, and while the stone in the part of the bed concealed may be uncertain in quality until further tested, that part of it exposed is as uniform in color and texture as any observed in the oölitic area.

In the southwest quarter of section 36 (8 north, 2 west), on the south side of Happy Creek, is a massive ledge of buff oölitic limestone, free from seams and flaws, the surface being so smooth and even that it is difficult to chip off a fragment with the hammer. There are a few streaks of coarsely fossiliferous stone, and in one place a compact, semi crystalline area, but all parts weather evenly. The stream has cut a channel into the rock, but in only one or two places has it undermined the bluff. (See Plate XX, No. 2.)

In the northwest quarter of section 36, on the north side of the small branch, is a promising outcrop of 25 to 30 feet of oölitic limestone, and more, how much is not known, concealed below the bottom of the valley. The stone is fine grained, uniform and durable, weathering evenly and in good position for quarrying.

On the southwest side of the same branch, about a quarter of a mile west of the above, is a massive ledge of the most solid, compact limestone observed in this region.

A mile south of Victor Postoffice, on the west side of Clear Creek and a few yards south of the wagon road, in the northeast quarter of section 13 (7 north, 2 west), a small watercourse has cut a deep narrow gorge into the oölitic stone, exposing a thickness of 25 to 30 feet of nice-looking stone, the bottom being concealed so that the total thickness is not shown. It varies somewhat in texture, part of it having a fine grain, other parts rather coarsely fossiliferous. The greater part weathers rather evenly on the face of the gorge, but in a few places is much corrugated and pitted, showing uneven weathering. The stripping here would be very light, as the slope back from the bluff is very gentle.

In the northwest quarter of section 13 (7 north, 2 west), is a large outcrop of stone similar to that mentioned above in the northeast quarter. It is exposed in several small tributary ravines, and shows a bed of stone not less than 40 or 50 feet thick, varying somewhat in texture at different points. In most places the upper surface is weathered to considerable depth, and will be found to be ridged and uneven, but much nice stone occurs in different parts of the bed.

The following drill records show stone of good quality in the localities mentioned. The appearance of the outcrop adds but little to the record of the drill. The quotations are from the certified records of the driller.

1. "In the northwest quarter section 19 (7 north, 1 west), 35 feet first-class buff stone. This is the first stone that I have drilled and found no flint, no crowfeet, no dries, or anything detrimental."

2. "N. W. S. W. section 19 (17 north, 1 west).

Dirt stripping	3 feet.
First-class buff	38 feet.

Two crowfeet near the bottom eight inches apart, and one six feet from the top."

3. "Southeast quarter section 24 (17 north, 2 west), 26 feet in buff stone of a very fine quality. This makes four (6½ feet) cuts without a thing to injure the stone except two small crowfeet close together about six feet from the top, and I can safely say there will be at least one more cut in the rise of the hill."

4. "Southwest quarter section 24.

First-class buff stone	32 feet.
Blue stone	12 feet.

Clear of any defect except two small crowfeet."

The Cleveland Stone Co.'s quarry.—A quarry of oölitic stone was opened and operated for a time, some years ago, by the Cleveland Stone Co., on the bluff east of Clear Creek, in the northwest quarter of section 20 (7 north, 1 west), a little more than a mile north of Harrodsburg. There was a branch run out from the Monon railway a distance of a mile and a half. The quarry was well equipped with machinery, and a great deal of work was done, but the venture was not a profitable one. The machinery was removed, the track has been partly torn up and the quarry abandoned.

The oölitic stone lies near the top of the hill overlain by eight to ten feet of soil, but no other rock covering, and has weathered deeply. Irregular openings, one to three feet wide, occur along nearly all the joint seams, extending in most instances to the bottom of the quarry. This causes a great quantity of waste. Added to this are a great many crowfeet seams, one or two in nearly every channel cut. The upper surface

is much ridged and corrugated. The upper part of the bed at the north end is quite hard, containing some chert, which is said to have interfered with channeling. A layer three to five feet thick a few feet from the top is very fossiliferous, containing a great many well preserved fossils. This layer rapidly disintegrates into a calcareous sand, with the fossils in the debris. The stone is all buff in color, no blue stone appearing in the opening.

The occurrence of the hard layer on the top, the fossiliferous disintegrating layer, the numerous crowfeet layers, and open vertical seams, all combined, produce too much waste to lift the little good stone with profit.

LAWRENCE COUNTY.

(Bedford and Vicinity.)

The oölitic limestone quarries of Lawrence County cluster around Bedford, in the north central part of the county. There are several stone mills but no quarries in the town of Bedford, the nearest quarries to the town being the Blue Hole quarries on the east side of town. There are no active quarries immediately south of the town, but there are east, northeast, southwest, northwest and north, the largest and most productive quarries being northwest of town on Buff Ridge and in Dark Hollow. Some of the largest quarries in the State, and among the largest in the United States, occur in this locality.

The quarries are located either on the main lines of or on switches connecting them with the L., N. A. & C. R. R. main line and Bedford, Switz City branch, the Belt R. R., the E. & R. R. R., and the B. & O. S W. R. R.

The stone varies in the different quarries, often in the different parts of the same quarry in thickness, color, hardness, and coarseness of texture.

Peerless Station.—The Peerless quarry, which was opened in 1890, is situated about four miles north of Bedford, in section 26 (6 north, 1 west), along the main line of the Monon Railway, with which it is connected by switch. It lies near the top of the hill, east of Peerless Station, on the east (south) side of Salt Creek.

There is no rock overlying the oölite, and as a result the upper part of the oölitic bed is very much weathered. The weathering agencies have penetrated along the joints and lines of weakness, making numerous irregular vertical fissures of varying width and depth, some extending but a few feet below the surface and some to the bottom of the bed. The rock is overlain by two or three feet of residual clayey soil, which also fills the fissures or open seams. Thus while there is but little rock stripping, there is a great deal of waste along the fissures, which likewise interfere with the channeling, and cause an additional expense outside of the mere waste rock.

The stone in the Peerless quarry shows considerable cross-grain, yet not sufficiently pronounced to produce a ready parting or cleavage on the false bedding, as in some other places. Except the cross-bedding, the stone is comparatively uniform in structure, grain and color, being fine-grained, equal to or below the average in fineness, and having a light buff color. The stone obtained is of good quality; it is merely a question of whether it can be worked profitably in competition with other quarries where there is less waste. It is well equipped with quarry machinery, but is not in operation at present (July, 1896).

The oölitic limestone, very similar in quality to that at the Peerless quarry, outcrops along the slope of the ridge east from the quarry and is exposed in considerable quantities along the wagon road a half mile east of the quarry.

There is a similar exposure on the hill a mile north of the quarry, in the northwest quarter of section 25 (6 north, 1 west), which has been core-drilled preparatory to further exploitation. The stone, as it appears in the outcrops, is of good quality, but, like that at the Peerless quarry, it is liable to have many weather seams, as it lies at the top of the hill with no other rock and little soil covering. The outcrop shows some massive ledges of fine stone.

Thornton's Quarry is in the northwest corner of section 34 (6 north, 1 west), a half mile southeast of Peerless Station and three miles in a straight line north of the northwest corner of the city of Bedford. It is connected by a switch with the Monon Railway and is not very distant from the Peerless quarry, which it resembles in some respects, being situated near the top of the hill, but it differs from the Peerless in having a heavier covering and hence fewer open seams and less waste rock. In the southeast corner of the opening is a bed of six or eight feet of overlying impure compact limestone, which bids fair to increase in thickness as the stone is quarried further back into the hill.

The contact of the oölitic stone and the overlying rock in Thornton's quarry departs from its customary regularity, as observed in most other places, and dips toward the southeast along both the east and south faces of the quarry. The false bedding likewise dips in the same direction but at a steeper angle than the line of contact. The bottom of the oölitic, which is not now exposed, is said by the quarrymen to dip in the same direction, as at the north end of the quarry the bottom of the lower channel is within 18 inches of the bottom of the bed, and 80 feet further south the bottom is four feet below the quarry floor.

The oölitic stone is about 25 feet thick, varying from two to four channel cuts in depth. The depth of overlying soil is two to four feet.

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The stone has a light buff color and medium fine grain, comparatively uniform both in grain and color, resembling the stone in the Peerless quarry. The quarry was opened in June, 1895, by the Bedford Steam Stone Works.

Buff Ridge quarries.—The Buff Ridge quarries rank among the oldest, the largest and the best along the entire oölitic limestone belt. There are at present four active quarries and three abandoned ones. Two of these, the Hoosier and the P., M. & B. quarries, are two of the largest quarries in the State.

Hallowell Stone Company's Quarry is a new one just opening on the southwest quarter of section 28, nearly half a mile northwest of the P., M. & B. quarry. There is no switch to the quarry and no stone has been shipped (July, 1896). The stone lies near the base of the hill on the north slope. The total thickness of the stone is not yet exposed, as they are only starting the second channel cut.

In the opening already made the stone is variegated buff and blue, the parting between the two colors being along a very irregular line. There is considerable cross-grain in some places, the stone having a perceptible cleavage along the false bedding. There are numerous small scattered crystals of calcite in the stone, in some places fine veins of calcite and in a few places iron pyrites along a cleavage plane.

As the slope is steep, there will be a heavy covering over the stone when it is quarried any considerable distance back in the hill and will probably be largely bluestone.*

The P., M. & B. (Perry, Matthews & Buskirk) Quarry, which was opened in 1889, is situated in the northwest quarter of section 33 (6 north, 1 west), nearly a mile north of the village of Oölitic and about three miles northwest of the city of Bedford. It is connected by a short branch with the Monon Railway at Horseshoe. The present quarry opening covers an area of between 25 and 30 acres and the company is stripping an area of several acres more on both the north and south sides of the quarry. It at one time consisted of several openings, which have run together until it is now all in one big quarry, with switches running to various parts of it and work going on at five different places, some of them two or three hundred yards apart.

The stone has been quarried in many places six or seven channel cuts deep—40 to 45 feet—the thickness of stone quarried depending generally on how much has been removed from the top by weathering agencies. There are a few, but not a great many, seams, the ones running east and west being nearly all vertical, while the north and south ones incline sometimes 10 or 20 degrees to the east. With the exception of one stylolite (crowfoot) seam near the top there are no horizontal seams or bedding planes of any extent.

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*Since the above went to press, I have learned that the quarry has been abandoned.

Practically all the stone quarried now is a light buff color. Some bluestone occurs near the middle of the quarry, but is not worked at present. Throughout the greater part of the quarry the stone has a uniform fine grain, but there are a few irregular patches where it is much coarser and more crystalline.

There is no overlying rock on the north side of the quarry, and the much weathered upper surfrce is covered with several feet of residual soil, through which points and spurs of the irregular upper surface of the rock project in places. On the south side of the quarry the oölitic stone is overlain by one to four feet of the close-grained, impure, rough, weathering Mitchell limestone, which in some places contains a fissile, shaly layer six inches to eight inches thick. The parting between the oölitic and the overlying stone is comparatively regular, so that on the south side the entire thickness of the oölitic stone is available.

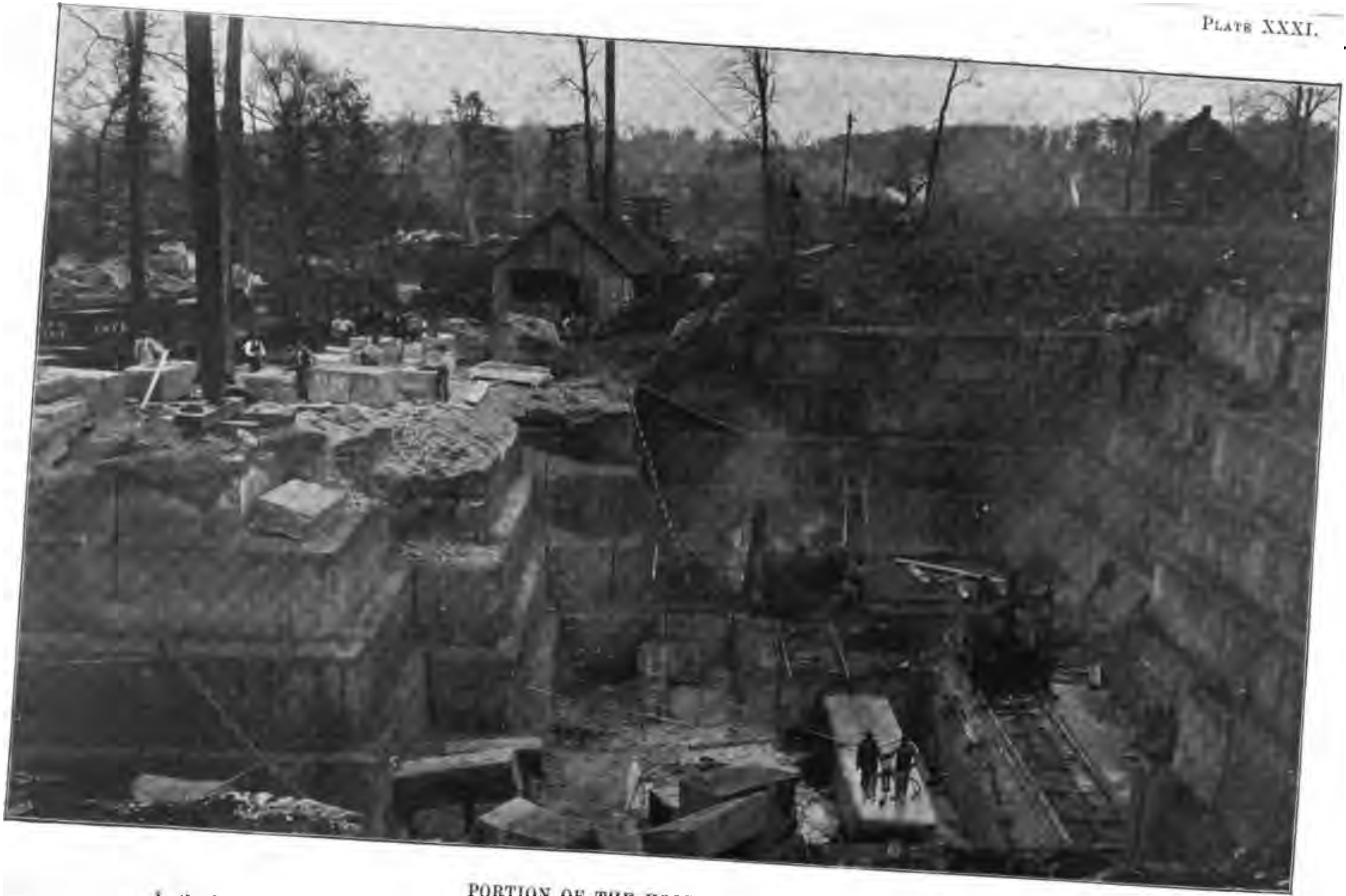
Hoosier Quarry No. 2 (now abandoned) is situated east of the P., M. & B. quarry, separated at the one corner by only a few yards of rock. The quarry opening is about 50 by 75 yards in extent and four, in some places five, cuts deep. It was opened by the Hoosier Stone Company in 1885–6, and among other contracts furnished stone for the Memphis bridge.

The character of the stone is very similar to that in the adjoining quarry, but there are more seams and heavier stripping. Besides the six feet of compact impure limestone similar to that in the adjoining quarry there is overlying that five or six feet of hard, much weathered oölitic limestone and two or three feet of soil, making 12 or 15 feet of stripping in all. The heavy stripping, along with the greater waste on account of seams, is probably the reason for abandoning the quarry.

In a few places the stone approaches a true oölite in texture, being made up almost entirely of small, rounded particles.

The Buff Ridge Quarry.—The Buff Ridge quarry lies about 150 yards southwest of the P., M. & B. quarry, on one terminus of the Belt Railway. It was opened by the Hoosier Stone Company in 1891. The stone is much like that in the adjoining quarries, a uniform, fine-grained, light buff-colored, semi-crystalline limestone. On the northwest side it is overlain by five or six feet of the compact rough weathering limestone, overlain in turn by several feet of compact oölitic stone and two or three feet of soil. At the south end there is no overlying rock, and the rough, deeply corroded upper surface of the oölitic stone is covered with the residual sandy clay. The stone has been quarried six cuts deep, the upper one being mostly waste rock.

In one place between the compact stone and the underlying oölitic is a layer of blue-brown shale six or eight inches thick. The quarry is a most promising one and is now (July, 1896) in active operation.



PORTION OF THE HOOSIER QUARRY.

In the foreground a long block has been turned over, which is being drilled preparatory to breaking into smaller blocks.

Hoosier (*"Old Hoosier"*) *Quarry* is one of the oldest and largest quarries in the district. It was opened in 1879 and has been in active operation ever since, having in that time produced immense quantities of stone, which has been shipped to all parts of the United States. From 1883 to 1892 it was operated by the Hoosier Stone Company; 1892 to 1894, by Bedford Stone Quarries Company; 1894 to 1897, by Bedford Quarries Company.

Like the large P. M. & B. quarry it consisted originally of several openings, which have since run together into one large opening covering about 25 acres, and five to seven cuts, 35 to 50 feet deep, in different parts of the quarry.

The stone along the south and east side contains at or near the top a layer five or six feet thick of the earthy, shaggy-weathering, impure Mitchell limestone, which apparently almost disappears on the north side. It is separated into two layers in places by the harder oölitic stone, and is quite hard and compact in some places, while in others it is friable, cavernous and contains considerable travertine. A thickness of several feet, including this so-called "bastard limestone," is waste material. Farther to the north this nearly, if not quite, disappears. The company has recently stripped over an area of several acres, and is now (July, 1896) beginning to channel at a level of 15 to 20 feet above the present quarry opening. So far as exposed, this stone appears to be coarser grained and lighter colored than the underlying quarry rock. It has a very irregular upper surface with numerous deep, weathered fissures. It is quite probable that much of this overlying rock will be waste material, but it is sufficiently thick to protect the underlying stone, thus affording a greater thickness of the handsome, fine grained oölitic stone. Plate XXII shows the channeler at work starting an opening in this part of the quarry.

On the south side of the quarry the top of the fine oölitic stone is much weathered, there being no overlying rock, the roughly corrugated surface being covered with residual clay and soil.

The stone throughout a large part of the quarry has a remarkably uniform fine grain and light buff color. Near the middle of the north side the bottom of the quarry is blue stone, of which considerable quantities have been removed. The blue stone quarried, however, is but a small part of the total product.

The quarry has been very successfully operated. The company, by quarrying at several places in the quarry and at several different levels at the same time, is prepared to take advantage of the slight difference in texture that may occur and at the same time prepared to rush an urgent job very rapidly.

The company disposes of vast quantities of its waste rock by having a large rock crusher to make it into railway and road ballast. The Belt railway is already ballasted with this stone and is probably one of the best ballasted pieces of road in the country. The spaces between the ties are filled up and the stone extends out about a foot beyond the ties. A top dressing of finer crushed material which has been put on this has hardened.

The Oölitic quarry, about 100 yards southwest of the "Old Hoosier," and the Brickyard quarry, south of the "Old Hoosier," have both been abandoned.

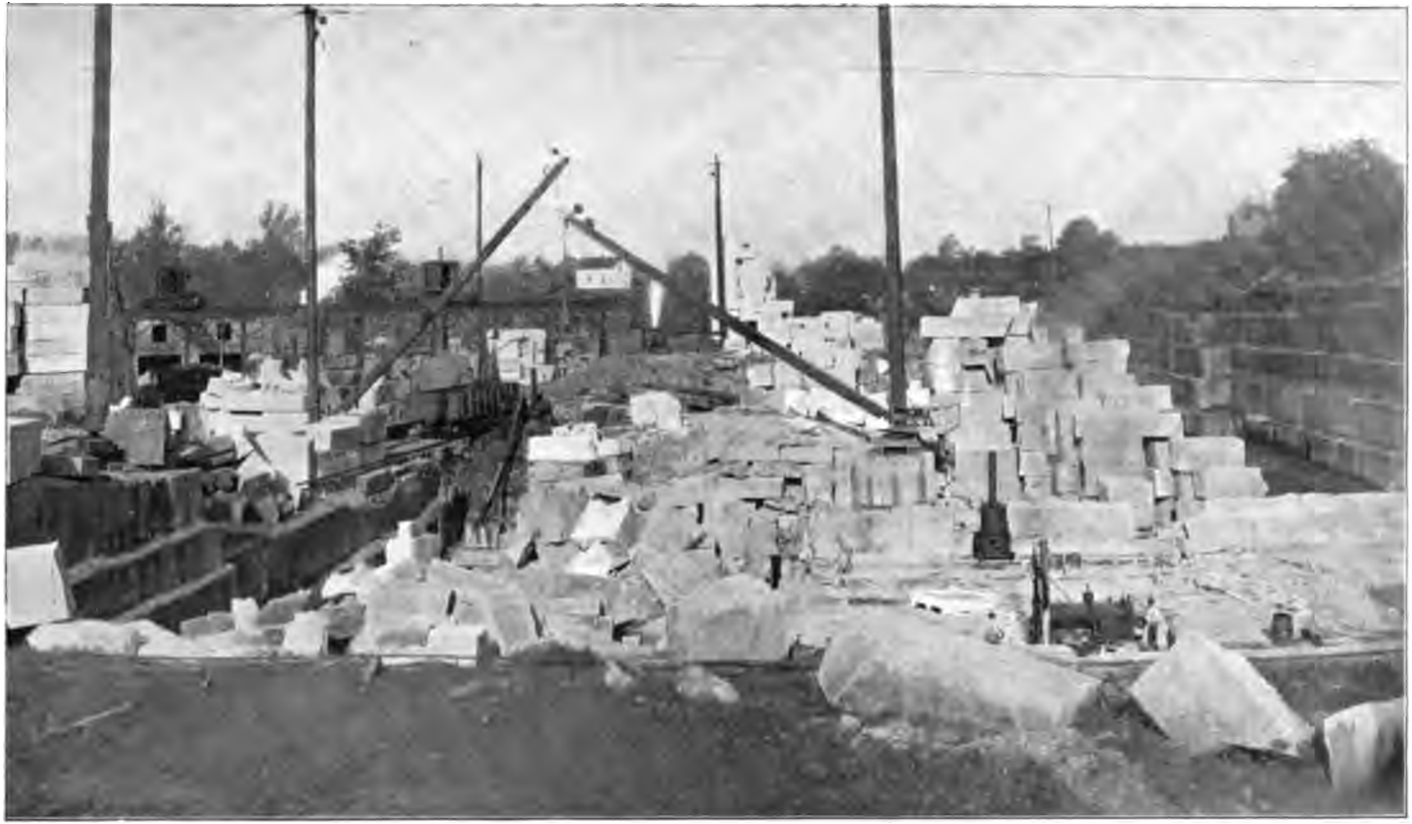
Reed's Station quarries.—David Reed was the first to open a quarry in this district, which he did in 1882, operating as the Bedford Quarry Company. Several openings were made and a well-equipped mill erected. A good business was done, and the little village, Reed's Station, grew up around the quarries. But when Mr. Reed secured the contract of stone for the Chicago Auditorium building he found that he could not get stone fast enough from this quarry, and the quarry at Sanders was purchased, as has been noted on page 370, since which time the property at Reed's Station has not been in such active operation.

The quality and character of the rock at Reed's Station is very much like that in the Buff Ridge quarries just described. There is, however, more waste rock and more stripping, the latter caused by the different topographic position of the stone. The Buff Ridge quarries are opened on the top of the hill where the stripping is not heavy. The Reed's Station quarries are on the north face of a higher hill on the opposite side of Goose Creek, and are quarried on the outcrop back in the hill until the expense of stripping becomes too great.

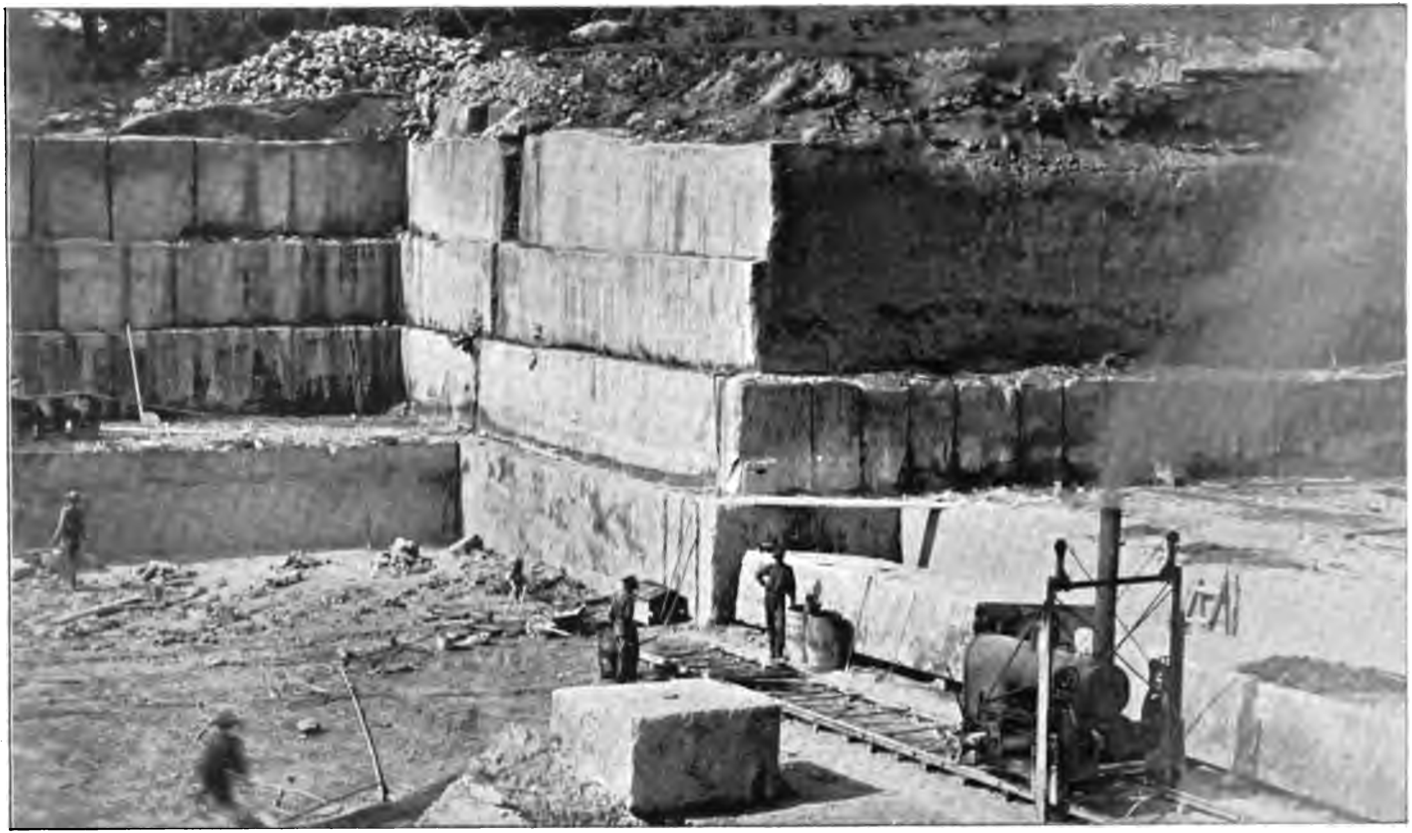
As is generally the case on bluff exposures, there are more weather seams than in openings made on the hilltops.

The quarries are all idle now except that belonging to the Bedford Indiana Stone Company ("The Robin Roost quarry"), which was opened in 1885 by Crim, Duncan & Co. In 1891 the property was disposed of to the *Indiana Stone Company*, which in time leased and later, March 15, 1893, sold the quarry to the Bedford Stone Company, which had previously purchased the Mitchell Hollow quarry. November 14, 1894, the Robin Roost quarry and associated properties came into possession of the Bedford Indiana Stone Company, which company is to-day one of the large producers of oölitic limestone.

The stripping along the abandoned face varies from 6 to 20 feet, consisting largely of the compact, clayey, rough weathering, impure ("bastard") limestone with, in places, streaks of hard oölitic limestone, but the latter in no place occurs in such quantity and quality as to have any commercial value, so that it all goes in with the waste. In one place the granular, compact rock overlying the oölitic is 6 to 10 feet thick, blue weathering to buff along the seams, and overlain by six to eight feet of light buff, compact, semi-crystalline limestone.



NORTHERN PORTION OF HOOSIER QUARRY, LOOKING WEST.
Showing method of quarrying, handling and stacking stone.



HOOSIER QUARRY, NORTHEAST CORNER.

Showing thickness of stripping, method of quarrying, and Wardwell channeler in operation.

The overlying rock is in places very fossiliferous, the fossils being remarkably well preserved, and the inclosing rock at the surface having disintegrated the fossils occur intact in the surface soil.

The rock is very much cross grained in places, conspicuously so at the north end of the Robin Roost quarry and in the abandoned quarry opening immediately north of the Robin Roost quarry. The cross-grain is so pronounced in places as to cause a cleavage along the planes. This is of local occurrence, as large quantities of good stone uniform in texture have been removed from the different quarries.

The greater part of the stone is buff, but the bottom of the deeper openings is blue. Where the opening is eight cuts deep the blue stone extends into the third cut from the bottom.

Large stylolites (crowfeet) occur in several places, which cause almost as much waste rock as the vertical seams.

On the outcrop, where not covered by the overlying impure limestone, the stone has weathered with a rough corrugated surface causing several feet of waste rock exclusive of the residual clay soil. At the abandoned quarries northwest of the station, numerous open weather seams penetrate the mass of the rock.

The thickness of the rock quarried varies in different places from two or three channel cuts to six or eight cuts (15 to 60 feet).

There are two mills here, Reed's at the station, and Bedford Indiana Stone Co., a quarter of a mile south of the station, having in all eleven saw gangs, three planers, one header and three steam travelers. There are six derricks, nine channelers (five idle July, 1896) and two drills.

DARK HOLLOW DISTRICT.

On November 24, 1877, shortly after the completion of the Bedford & Bloomfield Railroad (now a division of the L., N. A. & C. R. R.), the Dark Hollow Stone Company was organized and in May, 1878, opened the first quarry in the Dark Hollow district. This quarry was very successful from the start, and in three years' time had paid back in dividends an amount equal to its original cost. Their first large contract, and indeed the first large contract calling for Bedford stone, was for the Indiana State House. In 1890, this company was succeeded by the Dark Hollow Quarry Co. The latter company was forced by the recent business depression into a receivership. It was reorganized November 30, 1894, under the title *Consolidated Stone Co.*, the quarry becoming No. 3 of that company's quarries.

In the autumn of 1895, the Consolidated Stone Co. opened a new quarry, No. 4, just across the hollow from the older quarry, which promises to become a valuable property. See Plate XXIX.

The Hallowell Quarry lies immediately north of the original Dark Hollow quarry, the quarries each working up to the dividing line. It was first opened in 1878, by Hinsdale–Doyle Granite Co., to furnish buff stone for the City Hall of Chicago. In 1882 it came into the possession of its present owners, *The Hallowell Stone Co*

The Bedford Steam Stone Works opened a quarry in 1886, just northwest of the Hallowell quarry, but on the north side of Dark Hollow. It was abandoned at the end of 1893, and a new opening secured about three miles due north of Bedford.

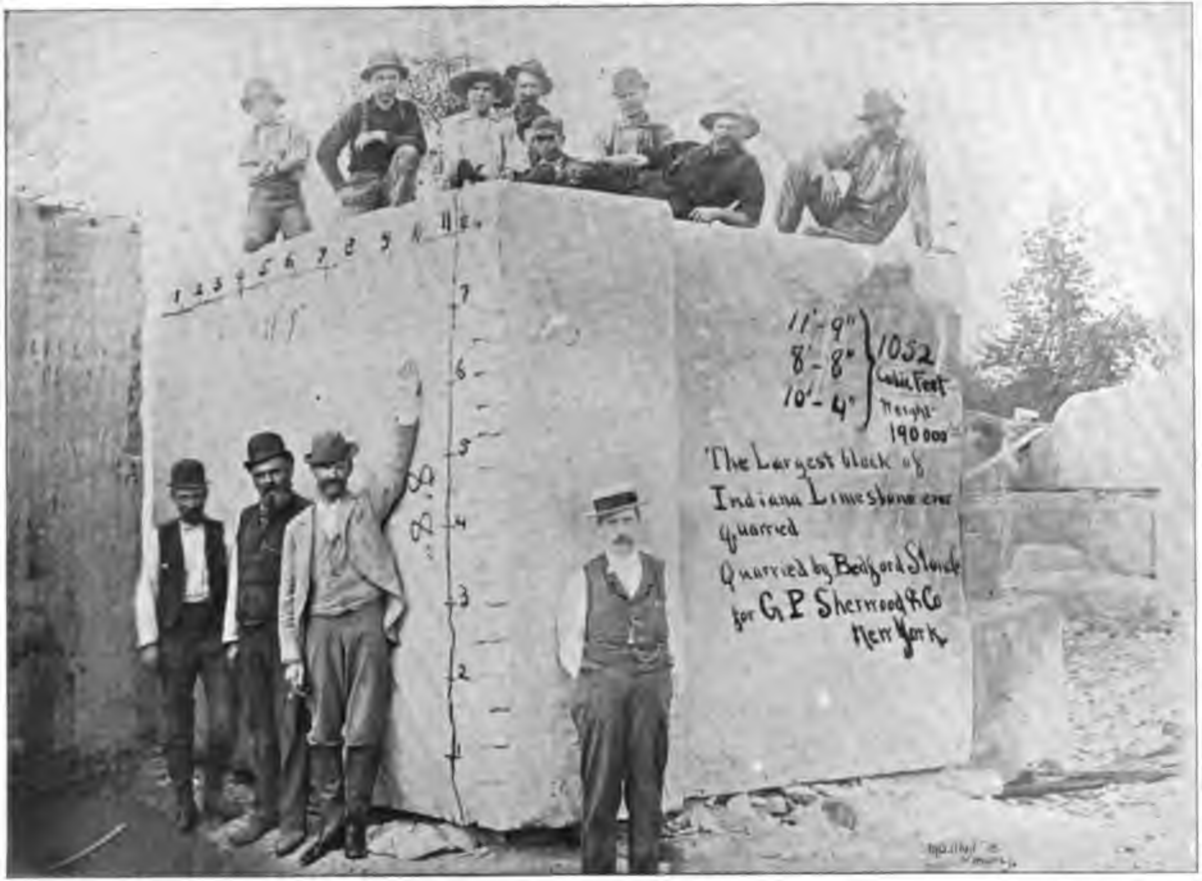
Both the Monon and the Belt Railroads have branches to these quarries. The Consolidated Stone Co. has a mill at one of their quarries, but the Hallowell Co. has its mill in Bedford, where the stone to be sawed, planed, or dressed, is sent.

The Hallowell Stone Co. uses the wire saw for cutting stone from the quarry, the only one used in the State. It was first tried a number of years ago and soon abandoned; later they used it in the yard for sawing blocks, and recently they have put it into use in the quarry again, where it is now (July, 1896,) in operation.

The oölitic stone is quarried on both sides of Dark Hollow, most of the quarries being on the south side. Thornton's quarry, the first one opened on the north side, is now abandoned. The Consolidated No. 4 has been recently opened on the north side, and is one of the most promising quarries in the State. It misses the mixed stone that stopped the other quarry on the north side of the hollow. The stone, as far as channeled, five cuts deep, is all buff of uniform grain and texture, very few seams and comparatively light stripping, three feet to five feet of soil and overlying compact rock. The slope back from the quarry is very gentle, so that a large area can be worked before the stripping becomes too heavy for removal. The oölitic limestone forms a bold outcropping ledge on either side of the quarry, which, while somewhat seamed and fissured, shows a comparatively bold outcrop with a face more even, smooth and regular than the average exposure. There are no horizontal seams, except a stylolite or crowfoot layer near the top, close to the contact with the overlying rock.

On the south side of Dark Hollow the quarries are along the face of the bluff and up a small ravine, and worked back into the hill until the thickness of the overlying material becomes too great for removal.

As is the case on the north side, the stone is remarkably uniform in texture and color. The stone is nearly all buff, a little blue occurring near the bottom in some of the openings. The vertical seams are remarkably even and regular, in many places almost as smooth as channel cuts, hence waste is very small compared with that where the seams are irregular and open.



IN THE QUARRY OF THE BEDFORD INDIANA STONE COMPANY.

The overlying compact limestone rests upon the oölitic with remarkable uniformity, in many places the parting between the two being marked by a stylolite (crowfoot) layer.

The Hallowell Company is now working on the remnant of rock left between their main quarry opening and the valley, practically on the outcrop of the rock. The comparative scarcity of seams here where ordinarily they would be more abundant speaks well for the homogeneity of the stone. There is considerable travertine in the abandoned opening west of the present working, which fills the seams and cavities in the rock.

In the Thornton quarry, the farthest one north, there is more blue stone than in any of the other openings. The greater part of the two upper cuts is buff and the large part of the remainder blue, but the buff follows the vertical seams through the blue, varying from a few inches to several feet. Likewise the blue frequently follows a stylolite (crowfoot) layer horizontally through the buff, thus causing great quantities of mixed stone.

The *Baalbec* quarry, though not exactly within the Dark Hollow District, lies near that district. It was first opened, shortly after the completion of the B. & B. R. R., by Hon. M. F. Dunn and Judge Francis Wilson. This was before the introduction of channeling machines, and when the firm worked back into the hill and struck a solid ledge which they were unable to work with the facilities at hand, they became discouraged and abandoned the quarry. The Baalbec quarry was leased in 1890 by the Acme-Bedford Stone Company and operated by them until 1894. In 1895 the Acme-Bedford Stone Company abandoned the Baalbec quarry and leased the B. & B. quarry in the Sanders District of Monroe County.

SPIDER CREEK QUARRIES.

Southwest of Bedford along the E. & R. Railroad there are several oölitic quarries, but only one, the Norton quarry, in operation at present.

The oölitic stone outcrops in the northeast quarter of section 22, township 5 north, range 1 west, close to the city limits, and from thence down Spider Creek Valley, both along the main creek and in the small tributary ravines to White River and along the White River bluffs.

In general the stone along Spider Creek is coarser grained and harder than that a little further north. It varies, however, in different parts of the valley and at different depths in the bed.

The West Bedford Stone Company opened a quarry and built a mill in 1892 about one-half mile northeast of the Norton quarry. The company ceased operations in 1893, and in 1895 the mill was purchased by the *Climax Stone Company* and moved to the northwestern part of Bedford between the E. & R. R. R. and the Bloomfield branch of the L., N. A & C. R. R. The quarry machinery proper is yet in position.

The exposed rock is badly disintegrated in places to a depth of two or three feet. In the interior on the fresh surface it is quite firm and coarsely crystalline, in places having small patches of semi-compact stone. The top of the bed contains a great many well preserved fossils, which remain in the residual material as the rock decays.

Both buff and blue stone occur. The oölitic stone is overlain by a compact sandy limestone, which is 10 feet thick on the quarry face at the base of the hill, and contains numerous fossils and cavities varying from a half inch to two or three inches in diameter, some of them lined with crystals, others not.

Norton's Bluestone quarry in section 22, northwest quarter of southeast quarter (5 north, 1 west), was opened by Cosner & Norton in 1888, and has been in continuous operation since that time, but since 1895 operated by the C. S. Norton Blue Stone Company.

The rock is more uniform in character than that at the West Bedford quarry. The quarry is on the bluff on the east side of a small ravine from the southeast, and on the present face has a covering of from 10 to 15 feet of compact limestone, the bottom being more or less sandy.

The stone has been quarried to a depth of six channel cuts, about 40 feet, the upper part of the bed containing many small cavities, and hence much waste. Below the second cut the stone is an almost uniform blue color, with but very little waste, as there are but very few seams, and those that do occur are close joints. The stone contains some cross-bedding and does not cut quite so easily nor to such a smooth finish as the finer-grained stone, but it presents a handsome appearance with either rock or tool-dressed surface. Most of the product is shipped to New York City and used for building purposes.

The railway cut on each side of Norton's quarry shows a somewhat similar stone, but more of the buff stone than in the quarry.

In the abandoned quarry opening across the creek from Norton's quarry, and about 100 yards below it, the stone is much more cross-grained and quite porous in places. It contains numerous stylolite (toe-nails) and seams, both horizontal and vertical, thus causing a great quantity of waste rock, probably the reason the quarry was so quickly abandoned. It was opened first by the Bedford Blue Stone Company in 1889, who made a second unsuccessful opening in 1893.

The stratified compact stone overlying the oölitic has numerous geodic cavities containing quartz crystals. There are also many small stylolites in this compact limestone, five or six layers in the space of a foot.

In the numerous railway cuts between Norton's quarry and the river the oölitic stone is almost universally coarse-grained.

There is an old quarry opening on the south side of the railway in the southeast quarter of section 21 (5 north, 1 west) where some stone was quarried years ago by hand. It is finer-grained than much of the stone along this valley, and much more uniform. The stone, both on the quarried and on the natural rock face, is smooth, regular, sharp-angled, and has the appearance of great durability.

There is an old limekiln on the north side of the railway in the southwest quarter of section 22 (5 north, 1 west).

The Bedford Building Stone Quarry (sometimes known as the Gowen or *Limekiln quarry*) is in a small ravine on the east side of the creek in the northeast quarter of section 28 (5 north, 1 west). The quarry was opened in 1891, but ceased operations in 1893.

The stone has been taken from two openings at the head of the ravine, and while large quantities of stone have been removed, judging from the outcrop, the quarry face and the dump piles, much of it has been waste.

The stone has been quarried to a depth of 25 or 30 feet. There are numerous seams, both vertical and horizontal, along which the disintegrating forces have been at work. Some of the vertical seams extend to the bottom of the bed, but the horizontal ones are confined to the upper part of the bed. The three bottom cuts (18 or 20 feet) contain sound, compact stone of rather uniform, coarse texture, but much variegated in color. While the blue stone prevails at the bottom and the buff at the top, there is much intermingling of the colors between the top and the bottom. Some patches are coarsely fossiliferous, containing large brachiopods and gastropods.

The oölitic stone is overlain by 12 to 15 feet of laminated, argillaceous blue and buff limestone containing numerous geodic cavities, which is overlain by 20 feet or more of compact "lithographic" limestone which has been quarried and burnt into lime at the north quarry opening. No particulars could be obtained as to the amount burnt or use made of it.

Good bluffs of oölitic limestone occur along the north side of White River west from the Limekiln quarry.

SOUTH OF BEDFORD.

Along the Monon Railway, south of Bedford, a quarter to a half mile or more south of the city limits, there are several abandoned quarry openings, which were operated many years ago, and from which considerable oölitic limestone has been removed, but all are now idle. Part of it has evidently been burnt to lime, as there are three abandoned kilns near the quarries. They are said to be among the oldest quarries in the region.

At the first quarry south of the town, on the west side of the railway, there is an exposure of 12 to 15 feet of solid oölitic limestone, overlain by 10 to 50 feet of compact (Mitchell) limestone. The oölitic stone is harder, more crystalline, less fossiliferous and freer from seams than the average, but there is too much material on top of it for it to have any economic value. The total thickness of the bed is not shown.

On the opposite side of the railway east of the limekiln, there has been a thickness of 10 to 12 feet of the oölitic stone quarried, along with 12 to 15 feet of the underlying (Harrodsburg) limestone, upon which the oölitic lies quite comformably separated by a stylolite (crowfoot) seam.

Along the railway, further south, half a mile south of the city limits, there are several rock cuts in which the oölitic stone is exposed in the bottom of the cut, overlain by 25 to 30 feet of compact limestone, which contains layers of partly oölitic.

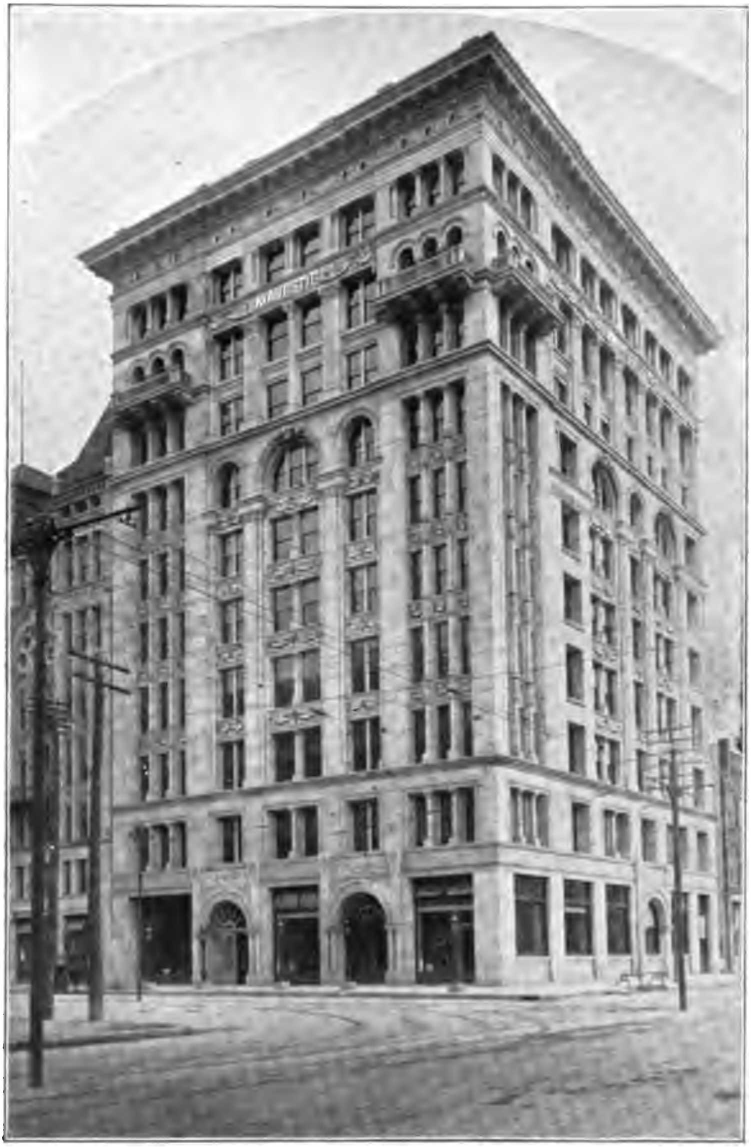
About a quarter of a mile south of the limekiln above mentioned, are two other limekilns on the east side of the railroad, and on the east side of the ravine opposite these kilns is the best exposure of the oölitic stone in this vicinity. Considerable stone has been quarried by hand. There is no sign of any channeling. It is probably as handsome a stone as any in the oölitic region, and one wonders on looking at the quarry why it was abandoned. It is true, the bed is thin, much below the average for the region—about 20 feet. But on the other hand there is little waste and little stripping. It is both overlain and underlain by a compact, dull-looking limestone. The thickness overlying varies from 0 to 3 or 4 feet along the bluff, and the slope back from the edge of the bluff is very gentle. Despite the fact that the bed is thin, it is a more promising locality than many that are worked elsewhere.

EAST AND NORTHEAST OF BEDFORD.

All the quarries east and northeast of Bedford, with one exception, were in operation the past summer (1896), but operated on a very small scale compared with what they had evidently done in previous years. There are two large quarries on the east side of Bedford bordering on the city limits, one of which, the *Blue Hole quarry*, ranks among the largest, the oldest and best known in the area.

The *Blue Hole quarry* was first opened by Nathan Hall, as has been previously noted. In 1878 the property was purchased by the Hinsdale Doyle Granite Company, who put in a complete equipment for quarrying, and built a switch nearly a mile long to the L., N. A. & C. railroad. Later the company was reorganized as the Chicago and Bedford Stone Company, in whose possession it now is.

The general features of the stone are similar to those south of Bedford. The bed is comparatively thin (from 20 to 30 feet), overlain by a compact, impure limestone, and underlain by the hard, semi-crystalline Harrodsburg limestone. The watercourses have cut deep ravines into



THE MAJESTIC BUILDING, INDIANAPOLIS, IND.

Constructed of Bedford Oolitic Limestone.

the limestone, exposing the oölitic stone near the heads of the ravines in and near the bottom, but the rapid descent of the streams leaves the oölitic bed on the slope of the hills, generally as a rather prominent ledge, down the ravine.

The most serious drawback to more extended operations is the heavy stripping. In both of the quarries east of town the oölitic stone has been quarried back into the bluff until the overlying material is 25 to 40 feet thick.

In the Blue Hole quarry work has been abandoned on the south side of the valley, and is being extended east along the north side of the valley.

The greater part of the stone has a fine, homogeneous grain, but there are a few streaks coarsely fossiliferous, a conspicuous one along the south side of the valley which shows plainly on the old channeled quarry face where it is scaling off or exfoliating. The scaling over the south wall extends to a height of 10 to 12 feet from the bottom, but is the worst in the coarsely fossiliferous layer. It is evidently due to freezing on the wet, fresh surface, as the waste stone in the dump shows no crumbling. There are several stylolite seams and a number of joint seams. Both the blue and the buff colors occur.

All the work in late years has been on the north side, where the stone appears to be uniform in texture and does not have so many stylolite seams. The few joint seams that occur are small, and there is comparatively little waste in the oölitic bed, but the stripping is very heavy. They are starting the fifth channel cut near the north end of the opening.

Immediately north of the opening of the Blue Hole quarry is an old quarry, the Nathan Hall quarry, said to be one of the oldest quarries in the region, worked many years ago, before the use of the channeler, when the work was done by hand. On the old quarry face and on the loose boulders the only effect of exposure observable is in the darkening of the surface.

The Benzel Quarry, opened by the Bedford Blue Stone Company in 1890, shows on the present quarry face six to ten feet of shelly, weathered semi-oölitic limestone underlain by 25 to 30 feet of compact impure limestone and 23 feet of clean oölitic stone, three or four feet of "soapstone" and 18 feet of hard blue semi-crystalline limestone which contains considerable carbonaceous matter and is now being quarried. They went down into this second channel cut this summer, but have quarried none of it for the market so far.

In the middle of the quarry the blue stone extends to the top of the oölitic bed, but at either end the buff stone occurs in the upper part of the bed. As the parting between the blue and the buff is quite irregular there is considerable mixed stone. The buff runs deeper at and near the joints.

The Brown Quarry. The Brown quarry, opened by the Bodenschatz-Bedford Stone Company in 1890, is about half a mile northeast of the city limits and more than a mile north of the E. & R. railway, with which it is connected by a branch joining the main line at the mill of the Bedford Stone Mill Company. The oölitic stone is thicker than at the Blue Hole quarries, but there is much more waste rock. There are more stylolitic seams and the joints are more deeply weathered than further south. There are two openings, one on each side of the railway track. The upper (eastern) one has been channeled five channel cuts deep. The one on the lower (west) side shows five cuts, and the bottom covered with water may conceal one or two more. There appears to have been very little stone quarried here this year (1896). The large amount of waste stone probably makes it unprofitable at the present price of stone. This stone is used for monumental purposes almost altogether, very little building stone being quarried.

The Salem-Bedford Quarry is about a quarter of a mile northwest of the Brown quarry and about half a mile northeast of the Salem-Bedford mill. The quarry was opened and the mill built in 1892. There are three separate openings, all of which are idle (July, 1896), whether permanently or temporarily abandoned is not known. The numerous stylolitic (crowfoot) seams and the irregularity of the parting between the buff and the blue are the objectionable features. Most of the stone that can be obtained free from these defects is good stone; only in one place was it found to be coarsely fossiliferous. The most promising opening of the three is the last one made, the one furthest west. Only two channel cuts have been made in it, the upper showing the weathering influences, but the second showing a fair quality of blue stone.

The Standard Quarry was opened in 1893 by the Standard Stone Company about one mile northwest of Bedford on a branch of the Bedford Belt Railway.

Both buff and blue stone are obtained of a medium fine uniform grain. The east-west joint seams are numerous, but are not much weathered, mostly close joints. The quarry stone is overlain by 12 feet to 15 feet of compact sandy and a coarsely crystalline limestone. The thickness of the oölitic stone is about 25 feet.

THE HELTONVILLE LIMESTONE STRIP.*

Commencing at Limestone Hill, eight miles southeast of Bloomington, and extending east of south through Heltonville to, and probably beyond, Fort Ritner, Lawrence County, is a band of limestone from one-half to one and a half miles in width, bordered sharply, both east and west, by Knobstone, and known in that neighborhood as the "Limestone Strip." Isolated patches of similar limestone occur north of this strip and in line with it. The strip is well developed in the vicinity of Heltonville, Lawrence County, where it gives exposures of the Harrodsburg, Bedford Oölitic and Mitchell limestones.

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*All the matter under this head and the Mitchell Hollow, Fort Ritner and Fishing Creek districts was written by Mr. Siebenthal.

At many points the Knobstone contains intercalated lenticular beds of limestone, and it is possibly conceivable that the conditions which prevailed while these beds were being deposited might have been extended over a narrow territory like the Heltonville strip. However the fact, first, that Knobstone has not been found overlying this limestone, and second, that it shows the lithological facies of the Harrodsburg, the Bedford Oölitic and the Mitchell limestones, and the faunas of these formations, identifies it with them and shows conclusively that it is a narrow band of those formations, occupying a depression in the Knobstone, and not an included member of the Knobstone.

This depression may have resulted from a double fault or may be an old erosion channel. Some things seem to point to one as the origin and some te the other. The facts at hand incline us to the latter view. The most palpable objection to this view is the fact that no non-conformity exists between the Knobstone and the Harrodsburg limestone at their contact a few miles west of the strip. Another objection is that the bottom of the channel, at present at least, is not at all of uniform elevation throughout its length. The principal objections to the view of a double fault are two—at no point was a direct vertical contact of limestone and Knobstone visible, nor was there to be seen any of the tilting, crushing and shattering which usually accompanies faulting. On the other hand, as the vicinity of the contact line is approached the shaly members of the limestone become more and more argillaceous and apparently pass over into the Knobstone. To determine the exact conditions under which the limestone strip was laid down would require more extended study than was consistent with the scope of this report. What has been done was to trace upon the accompanying maps the outcrop of the Bedford oölitic and to examine the bed more carefully at the places where it is now being quarried, namely at Heltonville and Fort Ritner.

The Heltonville Oölitic Limestone Company opened a quarry in 1890 in the vicinity of Heltonville, T. 6 N., R. 1 E., sec. 25, S. W. N. W. qr., which is equipped with two Wardwell channelers, steam drill, derrick, power, etc., and employs from 10 to 25 men. Three channel cuts six feet six inches each are made in fine-grained buff oölitic, and below that is channeled 10 feet of so-called Troy marble. The latter is a massive bryozoic development of the upper member of the Harrodsburg limestone. It does not take a very good polish owing to the openness of the bryozoa, but on a bedway face the lacework effect of the delicate bryozoa is very beautiful. Along the south bluff of Leatherwood Creek just north and east of the Heltonville quarry the oölitic is very fine grained and white. About a half mile up the creek from the quarry the limestone is shut off sharply by the Knobstone. The oölitic caps the ridge across the creek north of the quarry, as indicated on the map (Bedford sheet), and shows in two small patches in section 31 of township 6 north, range 2 east. South of these occurrences no oölitic is met with until in the vicinity of Fort Ritner.

SOUTHEAST OF BEDFORD.

Mitchell Hollow, Palestine, Fort Ritner, Rock Lick, Fishing Creek.

The Tanyard Stone Company, organized in 1890, opened the *Mitchell Hollow quarry* on the Bedford branch of the B. & O. S.-W. Railway, about three miles southeast of Bedford (T. 5 N., R. 1 E., sec. 30, sw. ¼). The quarry in 1892 passed into the hands of the Bedford Stone Company, by whom it was abandoned in 1893.

The oölitic limestone here is about 33 feet in thickness, overlain by a six-inch stratum of dark blue shaley limestone containing many small cup corals, which is in turn overlain by eight feet of massive, fine-grained buff and blue Mitchell limestone with a spongy weathering. The oölitic is divided by three bad toenail seams into four beds which, beginning at the top are respectively three feet, 16 feet, five feet, and nine feet in thickness. The upper bed is medium fine grained, mixed buff and blue, badly cross-bedded and fractures along the cross-bedding. The second bed is the principal quarry bed. It is of medium fine grain, but contains patches of much coarser stone, is badly cut up by vertical seams, and badly mixed buff and blue. These latter features caused the quarry to be abandoned. The third bed is rather coarse grained dark blue limestone. The fourth bed was concealed by water at the time of my visit, but is probably similar to the third bed.

The *Tanyard Creek Stone Company*, incorporated at Chicago in 1890, opened a quarry and built a mill on Tanyard Creek just north of Palestine Station on the B. & O. S.-W. Railroad. The property was sold in 1892 to the *White River Stone Company*, who made a new opening about a quarter of a mile southeast. This was sold under foreclosure in 1895 to the *Bedford Sterling Stone Company*, who are at present operating the quarry, known as the Tanyard or White River quarry. The stone has a rather coarse grain, and is both buff and blue in color, with considerable mixed stone, due to the intermingling of the two colors. Some of the blue stone is exceptionally dark in color, caused by an excess of carbonaceous matter. It acquires a deeper, darker color on exposure, possibly due to the heat of the sun drawing the carbonaceous matter to the surface. The stone has been quarried four channel cuts, about 25 or 26 feet deep.

There are no bedding seams except a stylolitic layer near the top of the quarry, and the joint or wall seams are not numerous. There is but little waste in the quarry, except from the mixed colors, which is waste only in first-class dimension stone, and may be used for bridge or foundation stone. The oölitic stone is overlain by four to 15 feet of sandy clay, which contains remnants of compact stratified limestone. There is a mill with two gangs of saws at the quarry. There is another smaller opening about 100 yards west of the one above described from which bridge stone has been quarried.

Fort Ritner District.—*A. Luedtke's* quarry is in the southwest quarter of section 11, 4 north, 2 east, about a mile and a half east of north of Fort Ritner. It works an isolated patch of oölitic similar to the occurrence at Heltonville and lying in the same limestone belt. The site was first prospected in 1858 by one Needham, who afterward located the Salem quarries. It was first opened in 1860 by George A. Smith, who shipped stone that year to Cincinnati for Lincoln Park. He was succeeded by Enoch Dixon, who operated the quarries many years, employing 10 to 15 men. Dixon was later succeeded by the present owner, A. Luedtke. The quarry has no switch connection, but the stone is hauled on wagons to the B. & O. S. R'y at Fort Ritner. The market has been mainly local, the stone being used for bridge piers, etc., and buildings in Seymour, Brownstown, etc. The ledge shows eight feet of good quality very light buff stone underlain by four to six feet of good blue stone, which takes a nice polish. The oölitic stone is overlain by a flaggy, blue stone which has been quarried extensively for flagging and curbing. A hand-power derrick is the only piece of machinery at the quarry.

C. Dixon's quarry, which lies just over the hill east of the Luedtke quarry near the center of section 11, 4 north, 2 east, has been but recently opened, and has about the same thickness of oölitic. The upper part is a very good quality, but the lower portion is coarser-grained and quite fossiliferous. Very little stone has been taken out except for a few monument bases, and there is not even a derrick at this quarry.

Rock Lick District.—Two quarries have been opened in this district, both abandoned several years since. The quarries are reached by a branch from the B. & O. S.-W. R'y, leaving the main line just east of Mitchell.

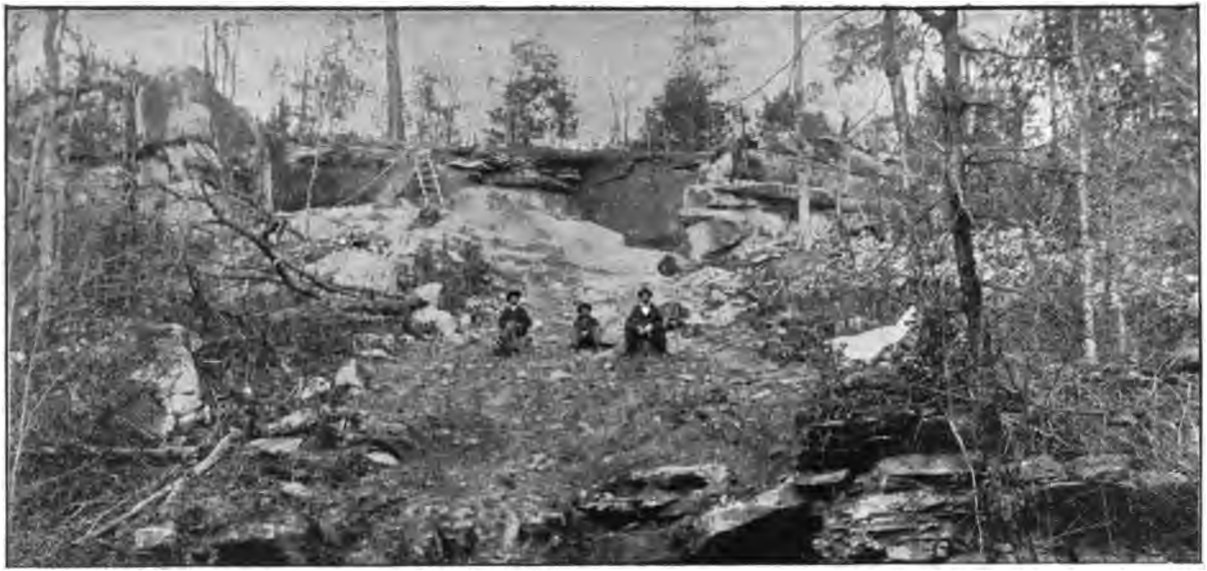
The first quarry opened was the *Big Four quarry.* The quarry which is near the center of section 31, 4 north, 1 east, was opened in 1889 by parties from Mitchell, and abandoned after three or four months. The oölitic limestone, which shows to a depth of 14 feet, is coarse-grained and has a very fetid odor on fresh fracture. Two cuts were channeled, which disclose many bad seams. The hill rises steeply from the quarry opening, and the stripping soon becomes very heavy. These causes led to the early abandonment of the quarry.

Leeds, Chanler & Starr, of Chicago, in February, 1890, opened a quarry 400 yards north of the preceding. Two five-foot buff cuts were made and taken out, and a third, a blue one, channeled but never taken out. The two buff cuts are traversed by three horizontal "toenails," which have thickening and thinning shaly places. Three large vertical seams run back into the bluff. The rock is very hard and injured by mixing of colors. It is not very fossiliferous. The total thickness is not less than 18 to 20 feet, which is above the average in this neighborhood.

Fishing Creek District.—The productive area of Fishing Creek includes the outcrop on both sides of the creek south from Lawrenceport for a distance of two miles. A good quality of fine-grained buff oölitic stone outcrops in the street in the south part of the village and shows at different points along the roadside south for a mile and a half. Where the Mitchell and Bono road crosses Fishing Creek at the south side of section 35, township 4 north, range 1 east, the oölitic shows to a depth of 30 feet on the west side of the creek and to a depth of 40 feet on the east side. The section exposed on the west side shows, eight feet from the bottom of the oölitic, three feet of shaly limestone and two feet of shattery limestone, which do not appear on the east side, where the grain also seems finer. Bores in this neighborhood report from 24 to 43 feet of buff oölitic. Along the drain which flows into the creek from the east, just south of the road referred to, the oölitic shows to a depth of 40 feet, the upper 15 feet of which is a fine quality of fine-grained oölitic and the remainder fair quality, all showing good weathering qualities. In the northeast, southwest quarter, section 2, 3 north, 1 east, the west bluff of Fishing Creek shows 36 feet of oölitic limestone, the upper 10 feet of which is fair medium, fine-grained, underlain by six feet of splendid fine-grained, underlain in turn by 20 feet of medium, coarse-grained, but fair quality of oölitic stone. The weathering qualities of each member is of the best. Taken all in all the Fishing Creek district is one of the most promising in the oölitic belt, and fully deserves the development which awaits it at no greatly distant date.

Salem and vicinity.—Time did not permit a detailed study of the area much south of Bedford or a detailed mapping of the area south of that shown on the Bedford sheet. But a brief examination was made of the Salem quarries and one or two others in the vicinity and the notes here recorded in the absence of more detailed work.

The quarry of the Salem Stone and Lime Company, now the Salem-Bedford Stone Company, is on the south side of the Monon Railway, about half a mile west of the town of Salem. The quarry was for many years worked quite extensively and produced some excellent building stone which went into fine buildings. The Georgia State House is constructed of this stone, as is the Salem Court House, one of the neatest



OUTCROP OF OOLITIC LIMESTONE ON BLUFF WEST OF TWIN CREEK, WASHINGTON COUNTY.

Harrodsburg limestone in the foreground. Bedford white limestone at the top.

court houses in western Indiana (see plate XXXVIII). There are a half dozen different but closely adjoining openings along the bluff running south from the railway on the west side of the branch road made by the company. The bottom of the stone is concealed either by water or debris at present, so that the total thickness of the stone is not shown. The walls show from three to five channel cuts, or from 20 to 30 feet, with three to 20 feet of rock and soil stripping. No stylolitic (crowfoot) seams were observed. There are a few incipient bedding seams and some cross-bedding, rather pronounced in a few places. There are a few joint seams, but they are neither large nor numerous.

The stone has a medium fine grain; no large fossils were observed. The greater part of the stone is buff, yet in a few places a little blue stone occurs.

There is a large stone mill and a number of limekilns at the quarry, but the mill is now idle. Most of the channelers have been removed and there appears to be very little dimension stone being quarried (1896).

A unique feature of this quarry is the absence of the large dump piles of waste stone, the universal accompaniment of the quarries elsewhere. The explanation of this is found in the limekilns at the quarry, where all the waste stone is burnt to quicklime and marketed in that form. The only stone that is being quarried at present (July, 1896) is the broken stone for lime burning (see p. 336).

On the north side of the Monon Railway, on the west side of Salem, there is a large quarry in the limestone underlying the oölitic (the Harrodsburg stone), where limestone is quarried and crushed in a steam crusher for railway ballast. Stone is shipped from this crusher at the rate of 80 to 100 cars per day (July, 1896). There are two varieties of stone—a compact blue stone with conchoidal fracture and a gray crystalline stone. At Spergen Hill, four miles east of Salem, is an outcrop of oölitic limestone famous for the great number of well-preserved fossils which it contains. It is probably one of the most prolific fossil localities in the State. Many of these fossils are pictured and described in the 12th Annual Report of the State Geologist of Indiana, 1882. The stone has but little economic value in this locality.

Twin Creek.—On Twin Creek, about two miles north of Smedley Station on the Monon Railway, and seven or eight miles north of west from Salem is a promising outcrop of oölitic limestone. It is exposed on both sides of the creek in bold cliffs at or near the top of the bluff, in some places forming perpendicular or overhanging ledges. There are clean exposures of not less than 25 to 30 feet* of oölitic stone and the total thickness may be greater than that, as in no one place are both the top and bottom of the bed clearly exposed. A few small stylolitic seams were observed, and there are a few joint seams, all of which appear to be regular. The weathered surface is in most places comparatively even and smooth.

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*Having no barometer with me, all the dimensions of this locality are estimates made by the eye.

The bluff at one place shows 25 to 30 feet of massive oölitic limestone overlain by 10 to 20 feet of coarse, partly oölitic laminated stone, overlain by 8 to 10 feet of earthy, sandy limestone overlain by blue limestone. The massive ledge has a fairly uniform texture of medium fineness and buff color. It appears to be a little more crystalline and harder than the stone further north.

The Twin Creek Stone Land Company of Salem, who own the greater part of this bluff on the east side of the creek, sent in samples for testing, the results on which show for the crushing strength:

Tested on natural bed, No. 1	11,700 pounds per square inch.
Tested on natural bed, No. 2	6,900 pounds per square inch.
Tested on natural bed, No. 3	11,100 pounds per square inch.
Tested on edge, No. 4	8,900 pounds per square inch.

The average of all being 9,400, the average on the natural bed, 9,900; but as No. 2 was an imperfect sample, the side chipping off before breaking, the average for the good specimens on the natural bed would be 11,400, a result higher than that for any of the other specimens of oölitic limestone tested in the same lot with one exception. The absorption shows it about equal to the average oölitic limestone in this respect, 1 in 31. Its specific gravity is a little higher than any of the other limestones tested. The chemical analysis shows it to be a very pure carbonate of lime, closely resembling the oölitic stone from other localities in this respect.

Chemical Analysis of Twin Creek Oölitic Limestone.[*]

	Per cent.	Per cent.
Residue insol. in acid	0.76	
Lime (CaO)	54.97	
Or lime carbonate ($CaCO_3$)		98.16
Magnesia (MgO)	.46	
Or magnesia carbonate ($MgCO_3$)		.97
Carbon dioxide (CO_2)	43.68	
Alumina and ferric oxide	.15	
Total	100.02	

There has not been sufficient work done in this locality to fully establish the quantity of good stone. However, the little work that has been done (see plate XXXVI) only strengthens the favorable impression that one gains from observing the outcrop. Unless defects are brought to light by further development, that do not now appear, we may expect to find

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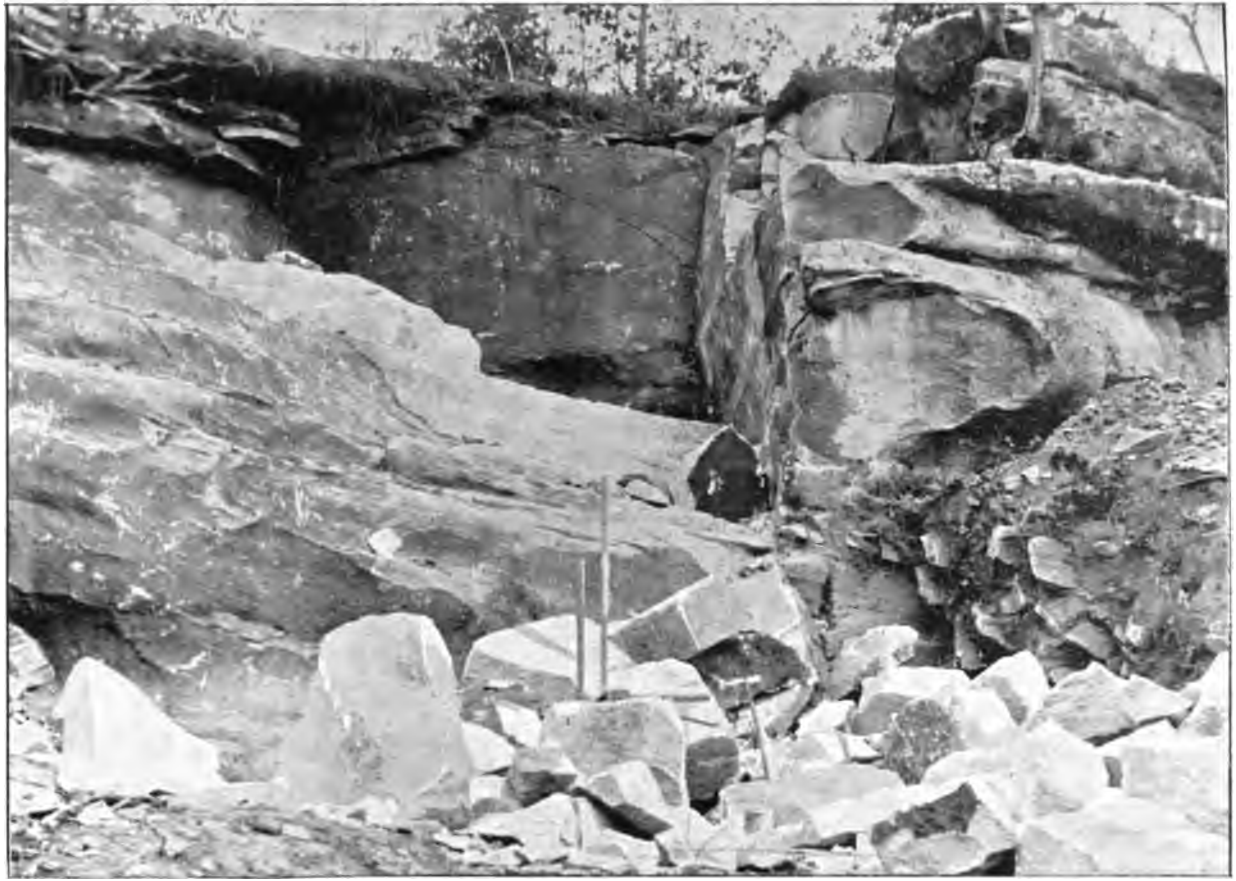
[*] Made by W. A. Noyes, Rose Polytechnic Institute, Terre Haute.



A NEAR VIEW OF PORTION OF THE BLUFF SHOWN ON PLATE XXXVI.

this a productive locality in the future. See the accompanying illustrations, plates XXXVI and XXXVII.

Stone for local use has been quarried on the bluffs on each side of Twin Creek for a number of years.

Oölitic stone is reported south from Salem to the Ohio River, but no opportunity was offered to examine it. So far as could be ascertained, it has been quarried at only one locality, Stockslager's quarry, near Mauckport, in Harrison County, on land now owned by David W. Jacobs. The quarry has not been operated for a number of years. A chemical analysis of the stone is given in the table on page 320. The stone is said to be whiter and more oölitic than that near Bedford. Some of it has been burned to lime and is said* to yield a pure white lime, which, besides its local use, is said to have been shipped south on the rivers to Mississippi and Louisiana for use in purifying sugar.

CHAPTER V.

OÖLITES AND OÖLITIC LIMESTONES IN GENERAL.†

Definition. The word oölite literally means egg-like, more specifically, like fish-eggs, and is used to designate rocks made up wholly, largely or partly of rounded particles, resembling fish-eggs in shape and often in size. The term *oölite* is sometimes limited to rock composed entirely or nearly so of the rounded particles, using the term oölitic limestone if there is much other material with the rounded particles. Hence we have the expression "more oölitic" or "less oölitic," as the proportion of rounded particles to the whole mass increases or decreases. The word is used with different signification by different writers, as will appear in the following pages.

The greater part of the literature on the subject is in German, particularly on the structural part. The French and English have written a great deal on the stratigraphy and paleontology of the oölite of Cretaceous age, but very little on the petrographic character of the rocks. The Americans have very little on the subject, as it is not a widespread formation in this country, and regions where it does occur have not been studied very thoroughly.

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*John Collett, Report on Harrison County. Geol. Surv. of Ind., 1878, p. 412, where a short description of the stone is given.

† There is no genetic difference between pisolite and oölite, the only distinction being that of the size of the constituents. As opinions differ as to where to draw the line, the pisolite will be considered in this paper simply as a variety of oölite.

The most specific treatment of the subject is in Zirkel's Lehrbuch der Petrographie, to which we are indebted almost entirely for the following classification.

Varieties of oölite.—On the basis of composition, oölites may be divided into calcareous, siliceous, argillaceous and ferruginous. The first is the largest and most important class, the others much more limited in their occurrence, and the following remarks refer almost wholly to the calcareous or lime oölites.

The little spheroids are sometimes made up of concentric layers, sometimes radially fibrous, sometimes both, sometimes neither. This gives a suggestion for a division of the subject into (1) oölites proper, (2) oölithoids, (3) pseudoölites.

I. *Oölites proper*, or oölites in the narrow sense, include those with a distinct concentric or radiated structure, and may include three varieties: (1) The first or Carlsbad type is made up of concentric shells of aragonite with no radial fibres, the negative vertical axes of the aragonite having a more nearly tangential direction, except in the outer periphery, where they stand radial. (2) In the second variety the spheroids are formed of more or less concentric layers, the individual layers consisting of small radial calcite fibres, which have a negative principal axis nearly radial, the usual structure of the oölite grains of the English Jura and the larger grains of the rogenstein. In the rogenstein a fine layer of clay often separates the individual layers of calcite. (3) A third variety has radiated, but no concentric shelly structure—many of the smaller rogenstein grains.

In all three of the above varieties the grains have a kernel of foreign material which may be quartz, feldspar, limestone, shell fragments, crinoid pieces, foraminifera, bryozoa, coral sand, or fragments of oölite itself. In the so-called Riesenoölite (giant oölite) of Sasso Mattolino the kernel of the large pisolitic grains consists of a coarse aggregate of either calcite or dolomite grains with stratified iron oxide.

II. The second generical class, *oölithoids*, or oölite in the broad sense, may be subdivided into four varieties:

1. Consisting of concentric layers of alternating zones of very fine crystals and coarse crystals. The layers may be alike chemically, but vary greatly in structure, color, shape and size.

2. A second variety in which the concentric structure is a marked chain-like folding upon one another.

3. The concentric separation of the inner part of the spheroid by foreign coloring matter.

There is no radial structure and no foreign kernel in any of these three varieties.

4. A fourth variety consists of those made up of many systems of tufted calcite rays thrust upon one another.

III. *Pseudoölites.* A third class, still further removed from the true oölites, is the pseudoölite which has only the outer rounded form in common with the other classes. Four varieties are given:

1. In which the rounded bodies have only a slight local difference from the matrix. An individual structure wholly wanting. The outer limits not sharply defined. This may consist of (a) very fine crystalline particles in a coarsely crystallized mass; (b) coarsely crystalline particles forming a rounded granular heap in a finely crystalline mass, and (c) the spheroidal parts formed by the concentration of the colored bitumen in the interior.

2. Oölitic grains consisting of rounded fossil fragments covered here and there with a thin coating of carbonate. The oölitic limestone of Indiana.

Steinman found these fragments covered with a thin coating having the microscopic structure of a sponge. In some of the older Tertiary the kernel of gasteropod shell is covered with a vegetable coating, Lithothamnium.

3. The apparently oölitic grains are only fragments of a crystallized granular limestone, polished by friction and cemented by limestone.

4. In a fourth variety the concentric coatings form on little insect eggs. Such were observed by Virlet d'Aoust in the seas of Chaleo and Tecoco in Mexico.

C. W. Gumbel* gives a three-fold division of the subject into 1, *Extoöliths*, those formed by outward growth from the interior; 2, *Entoöliths*, formed by inward growth or filling of a cavity, and 3, *Dimorphoölite*, a combination of the two where the interior of the shell is filled with crystalline material, and the exterior coated with concentric layers. This includes only the first division given by Zirkel, and does not recognize the other two divisions.

Prof. Merrill† says that oölitic limestone is made up of carbonate of lime in three forms: 1, minute subangular shell fragments; 2, concentric coatings; 3, colorless crystals filling interstices.

Geikie says (Text Book, p. 119), that oölite is a limestone formed wholly or in part of more or less perfectly spherical grains resembling the roe of a fish, each grain consisting of concentric shells of carbonate of lime, frequently with an internal radiating fibrous structure. He does not recognize Zirkel's oölithoids and pseudoölites.

L'Apparent distinguishes two varieties: 1, Extoölithes, and 2, Entoölites, as given by Gumbel.

Prof. Sorby, in his address before the British Association, described three types of oölitic grains: (1) Concentric, as the Carlsbad Sprudelstein; (2) radiate structure consisting of concentric layers of calcite with their principal negative axes arranged radially; (3) recrystallized from aragonite into calcite.

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*Neues Jahrbuch of Min., u. s. w., 1873, pp. 303-4.

†Stone, Vol. 1, p. 295.

Barbour and Torrey, in the American Journal of Science*, describe two varieties of Iowa oölite, one with concentric structure, another with a sort of brecciated spherule composed of mosaic of exceedingly small fragments cemented together about a center. They resemble each other chemically and microscopically, the distinction being a microscopic one.

Dr. Rothpletz, in the American Geologist,† describes a snow-white oölite of vegetable origin on the shore of Great Salt Lake, where the lime is inclosed in the form of rounded tubercles which often mass themselves into larger irregular tubercular bodies which always inclose numerous dead algæ cells.

He describes three varieties: (1) Irregular tubercular bodies; (2) spherical or oval forms; (3) long, thin rods. The rounded or oval forms are, both by their external form and by the microscopic structure, true oölites. Around an immense nucleus are laid concentric shells with radial arrangement of the calcite crystals. But minute scattered granules occur in both the nucleus and the shell. By dissolving the lime slowly in very dilute acid the granules remain behind in exactly their original position and are seen to be dead and crumpled Glœo capsa cells, thus showing the vegetable origin of the oölite.

Origin of calcareous oölites.—If we use the term oölite in its wide sense, we would expect the different varieties to be formed in different ways. Using the term in its restricted sense, however, we find different opinions as to the origin.

Geikie says each grain consists of successive concentric shells of carbonate of lime, frequently with an internal radiating fibrous structure, and was formed round some minute particle of sand, or other foreign body, which was kept in motion so that all sides could in turn become encrusted. Oölitic grains of this kind are now forming in the springs of Carlsbad; but they may, no doubt, also be produced where gentle currents in lakes, or in partially enclosed areas of the sea, keep grains of sand or fragments of shells drifting along in water which is so charged with lime as to be ready to deposit it upon any suitable surface.

Prof. Merrill expresses about the same views, stating that by the evaporation of sea water the pellicles were deposited on the little grains which were kept in gentle motion by the waves. After the elevation above sea water the crystalline parts were deposited. (Stone, April, 1889.)

Prof. Seeley, in Phillips' Manual of Paleontology, says there can be no doubt that the formation is due to the evaporation of the surface of the sea, so that a film was formed around some shell fragment and continued to increase in size as it fell through the water, until it sank to the bottom. This, he states, accounts for the uniform size of the grains in the same stratum.

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* Third Series, Vol. 40, p. 246.

† Nov., 1892, p. 379.

In a paper before the British Association (1888), the same writer states that oölitic texture might originate in many ways. He thinks that many oölitic grains are pseudomorphs. In the magnesian limestone grains of dolomite present all the characters of oölite. It is so common for large foraminifera to be the nuclei of oölitic grains in the Carboniferous limestone of England as to almost justify Dr. Carpenter's view that oölites are foraminifera limestone where the foraminifera are coated with calcite. The small size of some grains is due to the transforming power of the current which is assumed to have formed them by rolling. He remarks on the close resemblance of the internodal grains of the nullipores to oölitic grains. These grains show a concentric structure as well as a radiated tubular structure which would favor recrystallization such as commonly occurs.

In a private communication he states that his conclusion in regard to nullipores was the result of his examination of the weathered surface of the Portland oölite in the University of Cambridge and subsequent examination of many oölites in Great Britain and other parts of Europe. He believes there are several types of oölitic grains which can not be explained in this way.

Prof. Sorby (An. Add. Br. Assoc., p 44), says that the concentric sprudelstein of Carlsbad is not formed by the normal deposition of crystals from solution, but by the more or less mechanical accumulation of minute prismatic crystals, with their longer axes parallel to the surface of growth. The minute crystalline nuclei were mechanically accumulated round a center like the layers in a large rolled snowball. True chemical deposition may have been going on at the same time.

In recent oölites of Bahama and Bermuda the spherules were formed in water muddy from decayed shells and corals, and the purely chemical deposit served simply to collect the fragments into spherules. The grains show a granular and crystalline structure in varying proportion in different grains and different layers. Secondary crystallization has sometimes taken place since deposition.

The oölitic grains in the Jurassic rocks indicate the original deposition of calcite round nuclei gently drifted along by currents of the ordinary temperature which caught up more or less of the surrounding mechanical impurities.

Prof. Dana (in Corals and Coral Islands, pp. 153 and 156), describes two different formations of coral oölite. (1) The coral fragments on the beach are worn into sand grains and coated and cemented by alternate moistening and drying through the action of the tides. They form regular layers from a few inches to a foot in thickness, and consolidated to a line a little above high tide. (2) A second variety is formed on the islands above the action of the tide on the sand banks of wind drift origin, and consolidated by infiltrating waters.

The oölites on the shore of Great Salt Lake, as described by Dr. Rothpletz, are evidently of vegetable origin.

W. H. Thompson (in 16th An. Rep. Geol. and Nat. Hist., Survey of Indiana, 1888, p. 81), referring to the Indiana oölite, says that the more it is studied, the more it appears to be the result of calcareous sediment deposited at the bottom of a deep trough in an otherwise shallow sea. The minute shells are cemented together with a cement composed of fine fragment dust of other shells and an immediate setting of $Ca\ CO_3$, rendering the whole mass homogenous, elastic and resonant.

Maurice Thompson says (17th An. Rep., '91), the special conditions under which the Indiana oölitic limestone was deposited were a deep, still sea teeming with minute shell-bearing animal forms—a sea whose shores were lined with the deposits of still older seas from which the water took up the lime in solution which precipitated along with the animal remains as a cement.

A. Knop (Neues Jahrbuch, '74, pp. 281–288), laments the fact that little has been done to explain the origin of oölites, and finds but little literature on the subject. He says that oölites whose form and structure are very similar, may have an entirely different origin. The Carlsbad Sprudelstein is cited as an example of the inorganic origin. The infilling of cavities in melaphyre, basalt, etc., is cited as proof that the spherules may be formed from the periphery inward. He examined many oölites and found none incrusting quartz sand grains, the centers being generally filled with calcite.

Knop describes oölite grains formed by the deposition of lime on carbonic acid gas bubbles. He found considerable deposits of this kind in the watercourses by Nauheim. By observing in his aquarium the great army of young brood of a sort of Limnæus and the very few individuals that came from it, he saw in the great mass of empty shells heaped up at the bottom of the ditch, a source of oölite, which would be formed by filling up the interior and coating over the outside. He thinks this applicable to the hornstone oölites of the anhydrite group of Pforzheim and Durlack.

Virlet d'Oust is also of the opinion that oölites can originate through the filling of existing cavities. He was led to this view by observing on the shores of Mexican seas milliards of insects which laid their eggs, the crusts of which would form foundation for the inner incrustation.

Leopold Von Buch, in his description of the Canary Islands, considers the oölite to be formed of broken shell fragments rounded by the waves and solidified by the deposition of lime out of warm sea water.

Ehrenberg thinks that the oölite grains of many limestones are derived from foraminifera, whose shells are rarely well preserved.

An interesting and somewhat surprising explanation of oölitic structure is offered by Mr. Wethered* of England, viz.: That it is organic, formed by a concentric wormlike organism which he gives the generic name of *Girvanella*, and distinguishes two species in the carboniferous oölite and two in the Jurassic oölite.

The best examples occur in the Corralline oölite, where he distinguishes the following types of oölitic spherules: 1. A spherule with a minute loosely aggregated form of *Girvanella* tubules as a nucleus surrounded by an irregular sort of concentric arrangement. 2. The same form of *Girvanella* in loose aggregations or surrounding foreign objects. 3. A spherule made up of loosely aggregated, very vermiform tubuli, which are larger. 4. The nucleus consists generally of calcite, and the concentric arrangement has a granular crystalline appearance, in which occasional outlines of tubuli appear. 5. A spherule with well defined concentric arrangement around a nucleus. He states that it has been the object to produce evidence that oölitic structure is not always of concretionary origin. He is not prepared to maintain that it is all organic, but it may be.

As explained elsewhere in this paper, the Indiana oölitic limestone is a mass of fossil foraminifera and allied shell forms.

Distribution of calcareous oölites.—The principal deposits of calcareous oölites in the United States are in the Lower Carboniferous limestones in the Mississippi Valley. So far as known to the writer, none of any note occur in this country in any other formation. The oölitic limestone occurs in irregular insular areas of varying extent in Indiana, Kentucky, Illinois, Iowa, Missouri and Arkansas. The details of its occurrence, development and use are but little known. Despite its present and prospective value, comparatively little has been written on the subject. There are a few brief papers of a very general character in the Indiana Geological Survey reports; the name occurs in a few places in the Kentucky reports, once in the Illinois reports, twice in the Iowa reports, and several times in the old Missouri reports of 1873–74. Short descriptive articles of a more or less general nature on the oölitic limestone of Indiana have appeared in *Stone*, *Mineral Industry and Mineral Resources*, the first named containing a good illustrated article on the Bedford quarries.

Oölitic stone is said to occur in Kentucky in Christian, Caldwell, Mead, Grayson and Todd Counties. So far as could be ascertained from the literature and by correspondence, the only place that it is quarried to any extent is in the vicinity of Bowling Green, where a quarry has been in operation for a number of years. How extensively it is worked at present is not known to the writer, as letters addressed to the company elicited no reply. It may be like many other quarries in the country at present, not in operation. The stone is spoken of favorably in the Philadelphia markets. A short description of it in the *Mineral Resources of the U. S. for 1889-90*, p. 395, states that it closely resembles the oölite of Portland, England, both in appearance and composition. The Kentucky stone has 95.31 per cent. of the carbonate of lime, and the Portland stone 95.16 per cent. In places it is compact and semi-crystalline, and in some places composed almost entirely of oölitic particles.

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* Mr. E. Wethered on Oölitic Structure, in Quar. Jour. of the Geol. Soc., Vol. XLVI, No. 182, p. 270, May 1, 1890.

Oölitic limestone is said to occur in Illinois at Jonesboro, Union County, and to have been quarried to some extent at Rosiclare, Hardin County. (See anal. on p. 320).

A. H. Worthen* says: "The oölite beds of this group (St. Louis) in the vicinity of Rosiclare and elsewhere may be easily cut into any desirable form, are susceptible of a high polish and make a very handsome ornamental stone. At some localities this rock is beautifully veined with white calcareous spar." With an analysis by Henry Pratten in Vol. III, pp. 288, 289, Geol. of Monroe County, he mentions the occurrence of 15 feet of light gray, nearly white oölitic limestone in massive beds.

Oölitic limestone occurs in *Iowa* in Marion, Grundy and Des Moines Counties. It is not known to the writer whether it is now quarried to any extent or not. It was quarried at Kilbourne and Pella some years ago, and may be at present.

In Missouri oölitic limestone occurs in Andrew County.

In Arkansas it occurs in Independence County near Batesville, in Carroll County near Eureka Springs, and at two points in Madison County. At all these points it has been used for burning into lime. At two points it has been quarried in small quantities for building stone and that near Batesville has also been used for ornamental purposes. The Batesville stone is harder and more crystalline than any other oölitic limestone known to the writer. The Madison County stone is more oölitic, that is, contains a greater portion of rounded particles than any of the other varieties.†

In Alabama oölitic limestone is quarried rather extensively at Rockwood, Franklin County, about two miles west of Darlington on the Birmingham, Sheffield & Tennessee River Railroad. The quarries are known as the Darlington quarries, and connected by branch railway to the main line. They have been operated for a number of years by the T. L. Fossick Company. The stone is said to occur in a massive bed of great thickness and extent. It is quarried and sawed like the Indiana stone. The company has two large mills of eight gangs each. The stone in the sample furnished by the company is a very light buff and exceptionally fine grained, the oölitic particles being very minute. It has been used quite extensively for building in the South.

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* Geol. of Hardin Co. in Econ. Geol. of Illinois, Vol. 1, 1882, p. 318.

†For particulars see Vol. IV of the Annual Report for 1890 of the Geol. Surv. of Ark., by T. C. Hopkins.

In England oölitic limestone occurs in great quantities in newer rocks than the heavy beds in this country. They are of Jurassic age and divided into (1) the upper or Portland oölite, (2) the middle or Oxford oölite, and (3) the lower or Bath oölite. Building stone is obtained in large quantities from all three divisions, especially the first, which is one of the best known building stones in England. So far as known to the writer, it is not imported to this country in any appreciable quantity.

Similar stones of the same age as the English ones occur and are used extensively on the continent.

Oölitic limestone of Cretaceous age is reported from Brazil, South America.

Oölites of recent age occur on the Bahama and Bermuda Islands.

Siliceous Oölites—It may be interesting to note in this connection the occurrence of certain deposits of oölite that texturally resemble the calcareous oölites, but differ from them in composition by having silica in place of the lime. As these have been rather minutely described by previous writers, we shall simply give a brief resume of the published papers on the subject.

Probably one of the most widely known occurrences of siliceous oölite is that at State College, Centre County, Pennsylvania, where it occurs in chert segregations in the Lower Silurian limestones of Nittany Valley. Mr. George Wieland took such an active interest in the study of this rock, and in sending samples of it to all parts of the world that it is known locally as "Wielandite."

Four papers have been published on this oölite. The first in order of time was by Prof. Barbour and Mr. Torrey*, in which they give a brief illustrated description of some of the forms and some analyses. They give it as their opinion that it is derived from calcareous oölite by replacement, giving as proof two intermediate grades. One analysis shows silica 3.7 per cent., and lime carbonate 88.71 per cent , the other forming a sharp contact with the first contains silica 56.5 per cent., and lime carbonate 16.84 per cent., and the true siliceous oölite contains 95.83 per cent. silica and 1.9 lime, while a single granule from the siliceous oölite shows 99.99 SiO_2, the other .01 per cent. being iron. The spherules of the siliceous oölite are darker than the body of the rock, while in lime oölites they are generally lighter. They have a concentric structure of alternating light and dark bands around a real or imaginary centre. In some spherules the nuclei consist of organic remains, in others crystals or fragments of inorganic material.

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*The American Journal of Science, September, 1890.

The second paper on this Pennsylvania oölite is by Mr. George Wieland*, and contains a brief sketch of its geographical occurrence.

The third and most complete paper on the subject is by Dr. W. Bergt,† who recognizes two distinct varieties of the oölite; one, much like rogenstein, consisting of tolerably thickly pressed spherules about 1.5 mm. in diameter; the other, a finer-grained, less regular variety. In the first the spherules appear to the naked eye to have a dark kernel surrounded by a white ring. Under the microscope it shows a transparent middle surrounded by a white opaque border. It has generally a very regular circular outline, but it is sometimes elliptical. The centre consists of a rounded quartz grain which contains small dust-like fluid inclusions, air bubbles, hair-like streaks (rutile needles) rarely small crystals of green hornblende (?) and six-sided brown mica, which indicate an altered eruptive rock as a source of the quartz. Sometimes the centre is made up of a saccharoidal, colorless quartz aggregate, which bears no evidence of destruction in itself, but has the appearance of grains which have mutually hindered themselves in crystallization, similar in appearance to quartz in fine fissures.

Sometimes the finest grained substance appears as the inner kernel or immediately surrounding the quartz grain.

In some spherules elongated quartz individuals form a zone between the coarse and the fine-grained aggregate. In some of the spherules radiated fibrous chalcedony forms entire or partial zones.

The ground mass of the stone forming the cement binding the spherules together consists of drusy quartz with one end pointing toward the centre of the interspace. Occasionally in this ground mass appear incipient beginnings of spherules.

Sometimes the spherules appear to have dropped out and the cavity filled with drusy quartz or with a single quartz individual.

Another (second) form of siliceous oölite presents a different microscopic appearance. It has the quartz grain at the centre, but the surrounding aggregate of the first variety gives way to the peripheral prismatic quartz. A white or brown cloudy opaque amorphous silica occurs sometimes as an exterior or interior zone. In one form the larger quartz prisms set in like building stones in an arch.

Dr. Bergt says he finds no mention in literature of an oölite similar to this Pennsylvania oölite. Spherulitic forms occur in oölitic opal and chalcedony, but they can be in no way compared with the Pennsylvania oölite.

He raises the question: "Is it primary or secondary?" He does not agree with Barbour and Torrey that it is altered calcareous oölite, but thinks it is quartzified, spherulitic chalcedony. He did not see the kernels of organic remains mentioned by Barbour and Torrey.

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*In the Mineralogists' Monthly for November, 1890.

†Published in the Gesellschaft Isis in Dresden, 1892, Abhl. 15.

The fourth paper on the Pennsylvania oölites is by E. O. Hovey,* who also fails to find any of the organic remains mentioned by Barbour and Torrey, and says: "The rock was evidently made from clear quartz sand by the action of alkaline waters depositing silica in the form of chalcedony around the fragments or aggregates of fragments of quartz and making the cement between the spherules of the same substance, while some of the quartz grains were caught in this chalcedony cement without being made the nuclei of spherules."

In volume I (p. 382), Survey of the Fortieth Parallel, an oölitic chalcedony is described. It occurs at Cathedral Bluffs, Utah, at the top of a bed of impure limestone, 100 to 150 feet thick, the upper four or five feet being metamorphosed into chalcedony. The round grains vary from one-thirtieth to one-tenth of an inch in diameter, have a more or less concentric structure and a cryptocrystalline calcareous cement. They are probably crystallitic, and not organic, and may be related to calcareous sands, such as now occur on the beach of Great Salt Lake. (It might be noted that these Great Salt Lake oölites have recently been shown to be organic.) An analysis shows this oölite to contain 74.81 per cent. of silica and the remainder calcium carbonate.

Prof. Broadhead, in Report of Geological Survey of Missouri, 1873–'74, mentions a siliceous chert occurring in Madison, Cole, Morgan, Moniteau and Miller counties. Some of the white regularly rounded grains have a small pit in the center, some are solid. In some of the coarser varieties the grains stand in relief, in some of the finer ones the oölitic character only appears where it is magnified. Sometimes the grains decay first, leaving a spongy chert; sometimes the cement is first removed, leaving a loose mass of grains.

Oölitic chert is described by Dr. Irving in the Wisconsin Geol. Surv. Rep. as occurring in the Lower Magnesian limestone of Wisconsin. He says that the older writers speak of oölitic limestone, but so far as his observation goes he finds the limestone not oölitic, but carrying disseminated oölitic chert. (Vol. II, Wis. Geol. Surv., p. 550.)

At Eureka Springs, Arkansas, the writer found a fine-grained siliceous oölite in the magnesian limestone of Lower Silurian age, probably near the same horizon as the State College oölite.

Mr. Wieland speaks of finding a siliceous oölite in stratified layers near Rockwood, Roane County, Tennessee.

Siliceous oölite is reported † in rocks of Tertiary age in northern New Jersey.

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* Bull. Geol. Soc. Am., Vol. V, 1893, p. 627.

† E. O. Hovey, Bull. Geol. Soc. Am., Vol. 5, 1893.

In foreign countries, siliceous oölite occurs as oölitic hornstone in the Trias of the upper Rhine country,* in Assynt limestone at Dunness, England; at Bedford, England; in Belgium; at Aracara, Villa Nova, State of Sergipe, River Sao Francisco, Brazil; on the upper Paraguay; in middle Sumatra; in Siberia, and in Egypt.

Ferruginous oölites.—Oölitic iron ore occurs in German Lorraine at the base of the inferior oölite in a bed 10 to 80 feet thick, consisting of alternations of limonite, limestone and marl. The ore, which is called *minette*, contains 30 to 40 per cent. of iron. Oölitic iron ore occurs elsewhere in Europe and in many places in the United States in the Clinton formation.

Much of the beauxite in Arkansas and Georgia has an oölitic (pisolitic) texture.

Oölitic ice.—The neve or snow at the head of the glaciers frequently acquires an oölitic texture.

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* Knop in Neues Jahrbuch, Heft 3, pp. 281-288.

APPENDIX A.

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BEDFORD REGION.

No stone of any consequence was shipped from the Bedford region until after the close of the war, although the railroad was completed to that point in 1852.

The pioneers of the stone business in this section were Nathan Hall, Davis Harrison and John Glover. The quarry operated by Hall and Harrison was one-half mile east of Bedford and is now a part of the Blue Hole quarry of the Chicago and Bedford Stone Company. Up to the close of 1873 all the stone shipped from this quarry was hauled to Bedford by ox teams. The stone was at first sawed out by hand, later on by horse power, and still later a steam saw mill was erected.

The quarry owned by John Glover was alongside the railway and a mile south of Bedford. A switch was laid into the quarry and for a few years quite a heavy business was done here. The stone was of fine texture but hard and hardly free enough on its lower bed to be worked with profit by the methods of quarrying stone then in vogue.

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APPENDIX B.

BUILDINGS CONSTRUCTED OF BEDFORD OÖLITIC LIMESTONE.

The following list will give a good idea of the wide and extensive use of the Bedford oölitic limestone for building purposes. The list does not claim to be complete; it does not contain all, or nearly all, the buildings, but probably does contain the greater part of the large and public buildings in which the oölitic stone has been used. A considerable part of the stone is sold by the quarrymen to contractors in different parts of the country, and frequently the quarryman does not know in what buildings it is used. Not only is much of it used in this way in the large cities like New York and Chicago, but in the smaller ones as well. In a great many of the smaller cities in the eastern States the Indiana stone is used for trimmings with the local stone.

It is worthy of note, the large number of public buildings in which the oölitic stone has been used, not only in Indiana but in other States. Four State capitol buildings are constructed wholly or in part of it; 26 court-houses in Indiana, and possibly others of which we have no record; custom-houses, postoffices, hotels and other public buildings have used this stone profusely.

The large number of buildings (110 and 200 not enumerated) in New York City, which is only a part of the buildings in which it has there been used shows its popularity in that city, a popularity that is still on the increase, as nearly every large producer in the oölitic area gave New York as his principal market last year (1896). One of them stated that 80 per cent. of the buildings now in process of construction in New York are using Indiana stone. This can be taken with some allowance, coming as it does from an interested party.

The list is as authentic as we could make it, dependent as we are almost entirely on the different quarrymen for the data. It is to be regretted that we could not in all cases give the part of the building composed of Indiana stone. Where this could be obtained, it is given; where nothing is said, it is not known. The list shows the stone to have been used in 25 States and one Territory, and one foreign country. It has, no doubt, been used in most of the remaining States, but we have no data to that effect.

The list is given not simply to show its wide and extensive use in architecture, but as a convenient reference, as well, to architects, contractors, builders and others who may desire to observe the stone in use to see how it stands the exposure, how it harmonizes with other materials, how it is adapted for different parts of the structure, etc. It is arranged alphabetically by States, and by localities in the State, so that any one can see at a glance the buildings of oölitic stone in his vicinity.

LIST OF SOME OF THE BUILDINGS CONSTRUCTED OF BEDFORD OÖLITIC STONE.

ALABAMA.

Birmingham—Postoffice Building, Peerless Quarry.
Mobile—Convent Visitation, Standard Quarry.

ARKANSAS.

Ft. Smith—Postoffice Building, Peerless and Perry Quarries.

CONNECTICUT.

Hartford—Gas Company's office, Hoosier Quarry, Geo. Keller, architect.

DISTRICT OF COLUMBIA.

Washington—Church of the Messiah, P., M. & B. Quarry.
Gunter Memorial Church, P., M. & B. Quarry.
Levi G. Leiter's residence, P., M. & B. Quarry.
Schneider flat, Peerless Quarry, T. F. Schneider, architect.
Senator John Sherman's residence, Peerless Quarry, T. F. Schneider, architect.
Washington Post building, Peerless Quarry.

FLORIDA.

Tallahassee—U. S. Court House and Postoffice, ——— Quarry.

GEORGIA.

Atlanta—State Capitol, Salem Quarry.

ILLINOIS.

Bloomington—Court House, —— Quarry.
Charleston—Illinois State Normal School, Romona Quarry.
Chicago—Academy of Science Building, Lincoln Park, almost entirely from Adams' Quarry.
Armour residence, Michigan Avenue, Adams' Quarry.

Athletic Club, C. S. Norton Blue Stone Quarry.

Auditorium Building, entirely, Reed's Oölitic Quarry.

Blair residence, Reed's Bedford Quarry.

Church of the Holy Angels, Hoosier Quarry, James J. Egan, architect.

Criminal Court, Reed's Oölitic Quarry.

City Hall, Hallowell Quarry and Blue Hole Quarry.

Lewis Institute, Hoosier Quarry, Henry Ives Cobb, architect.

Mandel residence, Dearborn Avenue and Division Street, Dark Hollow Quarry. First oölitic stone used in Chicago.

Polish Catholic Church, North Side, Adams' Quarry.

Public Library, Reed's Oölitic Quarry.

Pullman Building, Blue Hole Quarry.

Ex-Mayor Roache's residence, West Bedford Quarry.

Martin Ryerson Building, Reed's Oölitic.

St. James M. E. Church, 47th St. and Ellis Ave., Adams' Quarry.

St. Martin's R. C. Church, Hoosier Quarry, Schlacks & Ottenheimer, architects.

Stensland Building, Hoosier Quarry, Hill & Woltersdorf, architects.

Studebaker Building, Blue Hole Quarry, Henry Ives Cobb, architect.

University of Chicago (9 buildings), Adams' and Hoosier Quarries, H. I. Cobb, architect.

Y. M. C. A. Building, La Salle St., P. M. & B. Quarry.

Art Institute, Salem-Bedford Quarry.

The oölitic limestone has been used in a great many buildings, generally fronts or trimmings, where it is put in by contractors who purchase from the quarrymen, and there is no means of finding where the stone has been used. Following are some of the buildings in which it has been used, and there are many others: Illinois Central Railway Depot, New Cook County Jail, Art Museum, Standard and Lakeside Clubs, The Temple, Title Guarantee and Trust Co. Building, Jos. H. Walker Building, A. H. Revell & Co. Building, Security Building, Adams Express Building, St. Joseph Hotel, and a great many residences, including Potter Palmer's, A. V. and G. A. Armour's and others on the Lake Shore drive.

De Kalb—Northern State Normal School, Hoosier Quarry, C. E. Brush, architect.

Effingham—M E. Church, Thornton Quarry.

Galesburg—Postoffice Building, Peerless Quarry.

Greenville—Bond County Court House, Matthews Bros'. Quarry.

Rock Island—Court House, Consolidated Stone Co's. Quarries, Bloomington and Bedford.

Springfield—State Capitol, Perry's Quarry and C. S. Norton's Quarry (large carved pilasters).

INDIANA.

Anderson—Masonic Temple, Adams' Quarry.

Bedford—Lawrence County Court House, quarries near Bedford

Bloomington—Indiana University, Maxwell Hall, P. M. & B. Quarries.

Indiana University, Kirkwood Hall, Adams Quarry.

Adams Residence, Adams' Quarry.

P. K. Buskirk's Residence, P. M. & B. Quarry.

I. N. Batman's Residence, Empire Quarry.

Hill Block, Buskirk Block, Empire Quarry.

Bee Hive Store, Empire Quarry.

Monroe County Court House, base. Local quarry abandoned.

Carthage—Public School Building, Adams' Quarry.

Columbia City—Whitely County Court House, Hoosier Quarry.

Columbus—Bartholomew County Court House, Matthews' Quarry.

Crawfordsville—Wabash College Building (in part), Matthews Bros.' Quarry.

Evansville—Custom House and Postoffice, Matthews Bros.' Quarry and Perry Bros.' Quarry.

Asylum for the Insane, trimmings, etc., Matthews Bros.' Quarry.

Vanderburg County Court House, ——— Quarry.

Vanderburg County Jail, ——— Quarry.

Frankfort—Clinton County Court House, Matthews' Quarry, Perry's Quarry.

Franklin—Johnson County Court House—Matthews' Quarry, Perry's Quarry.

Greenfield—Hancock County Court House, Matthews' Quarry, Wing & Mahurin, architects.

High School Building, Matthews' Quarry, Wing & Mahurin, architects.

Greencastle—DePauw University Buildings, Matthews' Quarry, trimmings.

Indianapolis—Anschutz Building, Bedford, Ind., Quarry.

F. M. Bachman's Residence, 13th and Meridian Streets, P., M. & B. Quarry, trimmings.

Victor Backus' Residence, Perry's Quarry, first story stone.

Blacherne Flat, P., M. & B. Quarry, trimmings.

Capitol (1878–1888, $1,800,000), State House Quarry, Kannamaker & Denig, two miles south of Romona; Matthews' Quarry, Perry's Quarry, Terre Haute Quarry, Dark Hollow Quarry, principal part.

Chalfant Flat, P., M. & B. Quarry, trimmings.

Bishop Chatard's Residence, 14th and Meridian Streets, P., M. & B. Quarry.

Church of the Sacred Heart, Union and Palmer streets (trimmings), P., M. & B. Quarry.

Citizens' Street Railway Co.'s Office, P., M. & B. Quarry, trimmings.

City Library Building, Hoosier Quarry.

E. F. Claypool Residence, 186 North Meridian, probably Big Creek Quarry (1859).

Commercial Club Building, Hoosier Quarry.

Conduit & Sons Block, Matthews' Quarry.

Cordova Building, P., M. & B. Quarry.

Frank M. Dell Block, P., M. & B. Quarry.

English Hotel and Opera House, Ellettsville Quarries.

Fahnley & McCrea Block, Perry's Quarry.

Fahnley residence (1860-62), 200 North Meridian Street, Big Creek Quarry.

Fletcher's Bank Block, Perry & Matthews Quarries, P., M. & B. Quarry (addition).

Gramling Block, 35 East Washington Street, Perry's Quarry.

Griffith Block, East Washington Street, Perry and Kostenbader Quarries.

A. C. Harris residence, North Meridian Street, Terre Haute Quarry, rejected stone from Soldiers' Monument.

Harrison's Bank Building (1856; now torn down; was the first oölitic brought to Indianapolis; sawed pillars) site of new Stevenson Block, Big Creek Quarry.

Indiana National Bank Building, P., M. & B. Quarry, Consolidated Stone Company, blue base course.

Indianapolis Water Company power house, P., M. & B. Quarry, trimmings.

Indiana Trust Company Building, Perry, Dark Hollow and Bedford (Ind.) Quarries.

Insane Asylum, Matthews' Quarry, trimmings.

Lemcke Building, Bedford (Ind.) Quarry, trimmings.

Col. Eli Lilly's residence, P., M. & B. Quarry.

L. E & W. Railway offices, Blue Hole Quarry, trimmings.

Majestic Building, Bedford Indiana Quarry (38,000 cubic feet oölitic).

Malott Building, 11 and 13 East Washington Street, Matthews Quarry. Burned out, leaving only front wall standing. All but a few blocks were cleaned up and used in rebuilding. Fifth story was damaged most.

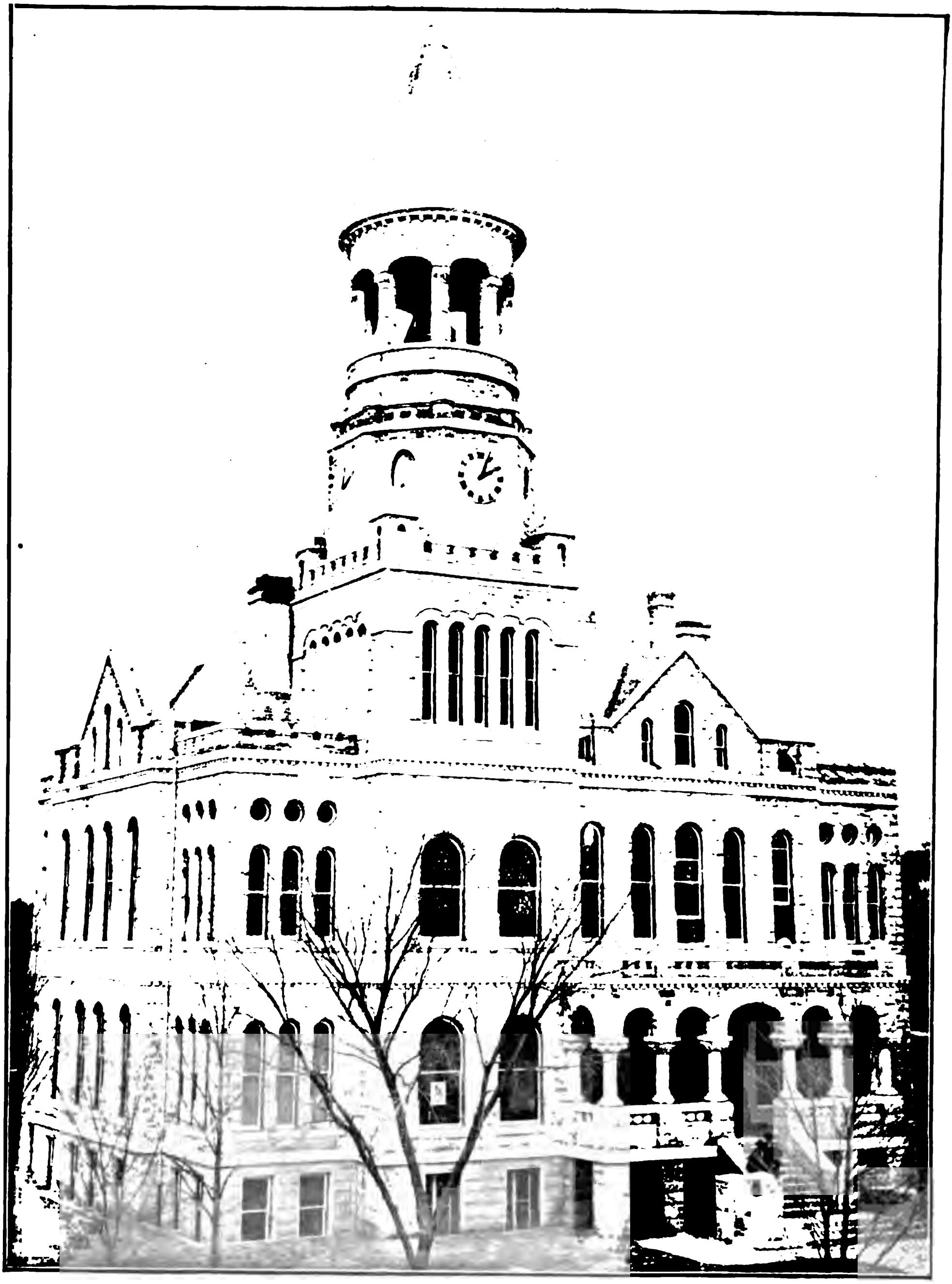
Marion Block, Perry Quarry, trimmings.

Marion County Court House, Hight's Quarry, Sharp & Hight; Matthews Quarry, Perry Quarry.

Marion County Jail, Hoosier Quarry.

McCormick Building, Blue Hole Quarry (trimmings).
McOuat Block, Kentucky Avenue, Needham's Quarry.
New York Store Building, P., M. & B. Quarry.
Occidental Hotel, Ellettsville Quarries.
Ex-Governor A. J. Porter's Residence, corner 9th Street and Capitol Avenue, Ellettsville Quarries, 1867.
Postoffice Building, Big Creek Quarry.
Propylaeum, Romona Quarry, P. M. & B. Quarry.
Richardson's Residence, 162 North Meridian Street, Dark Hollow Quarry.
Roberts Park M. E. Church, 1873, Perry's Quarry, Kostenbader's Quarry, Cornelius' Quarry.
Rush Block, Perry's Quarry.
St. John's Cathedral (trimmings), Elletsville Quarries.
Sayles Building, adjoins Malott Building. Burned at same time as Malott Building, but wall was light and stone too badly damaged to use again. Bedford Indiana Quarry.
Scottish Rite Temple, two lower stories oölitic; Perry Quarry.
C. F. Smith Residence, 13th and Delaware, P. M. & B. Quarry. Fine porch only of oölitic.
Soldiers' Monument, Terre Haute Quarry.
Schriever Building, corner Prospect Street and Virginia Avenue, Perry's Quarry.
Thorpe Block, Ellettsville Quarries.
Tomlinson Hall, Perry's Quarry, G. K. Perry (trimmings).
Willoughby Building, corner Ohio and Meridian streets, P., M. & B. Quarry.
Y. M. C. A. Building, Romona Quarry.

Lafayette—Tippecanoe County Court House, ——— Quarry.
Lawrenceburg—Dearborn County Court House, Perry's Quarry.
Liberty—Union County Court House, Thornton's Quarry.
Logansport—Insane Asylum, Matthews' Quarry.
Cass County Court House, Hoosier Quarry.
Soldiers' Monument, Hoosier Quarry.
Marion—Grant County Court House, ———.
Michigan City—Public Library, Consolidated Stone Co.'s Quarry.
Monticello—White County Court House, Star Quarry.
Mt. Vernon—Posey County Court House, Perry's Quarry.
Muncie—Grand Opera House, ——— Quarry.
Hon. Theo. Rose's Residence, Adams Quarry.
New Albany—Floyd County Court House.
Oldenburg—Sisters of St. Francis, P., M. & B. Quarries. Four buildings: Church of the Sisters of St. Frances, House of the Mother Superior, infirmary, power house.



SALEM COURT HOUSE, FROM OOLITIC LIMESTONE QUARRIED AT SALEM, IND.

Princeton—Gibson County Court House, Perry's Quarry.

Rensselaer—Jasper County Court House, Matthews' Quarry. Grindle & Weatherhogg, architects.

Richmond—Wayne County Court House, Hoosier Quarry.

Rochester—Fulton County Court House, Consolidated Stone Company's Quarries.

Rushville—Rush County Court House, Consolidated Stone Company's Quarries.

St. Mary's of the Woods, P., M. & B. Quarries. Six buildings: Church of the Immaculate Conception, House of the Mother Superior, Priest's residence, hotel, power house, bakery; fancy rustic bridge.

Salem—Washington County Court House, Salem Quarry. (See plate XXXVIII.)

South Bend—Presbyterian Church, Thornton's Quarry.

Clem. Studebaker's residence, Thornton's Quarry.

Terre Haute—U. S. Government Building, ——— Quarry.

Tipton—High School Building, Thornton's Quarry.

Valparaiso—Porter County Court House, Perry's Quarry.

Vincennes—Knox County Court House, Perry's Quarry, Matthews' Quarry.

Warsaw—Kosciusko County Court House, Perry's Quarry.

IOWA.

Cedar Rapids—Union Railway Station, Consolidated Stone Company's Quarries.

Sioux City—P. O. Building, Consolidated Stone Company's Quarries.

KANSAS.

Topeka—State Capitol, in part, Salem-Bedford Quarry.

KENTUCKY.

Covington—Cathedral, Hoosier Quarry, Leon Coquard, architect.

Danvillle—M. E. Church, Thornton's Quarry.

Georgetown—M. E. Church, Thornton's Quarry.

Lexington—W. S. Barnes' residence, Thornton's Quarry.

Louisville—The following are some of the buildings in which Bedford oölitic limestone has been used, quarry not known: U. S. Custom House and Postoffice, Louisville Medical College, German Insurance Bank, Fonda Block, Kentucky National Bank, Court House, and H. Strater's residence.

Paducah—Christian Church, Star Quarry; M. E. Church.

Richmond—P. O. Building, Peerless Stone Company.

LOUISIANA.

Baton Rouge—P. O. Building, Salem-Bedford Quarry.
Monroe—U. S. Government Building, —— Quarry.
New Orleans—Cotton Exchange Building, Hallowell Quarry.
Opelousas—U. S. Government Building, —— Quarry.
Shreveport—U. S. Government Building, —— Quarry.

MASSACHUSETTS.

Boston—Algonquin Club Building, Hoosier Quarry, McKim, Meade & White, architects.
International Trust Co., Hoosier Quarry; Consolidated Stone Co. (Both claim). Wm. G. Preston, architect.
Beaconsfield Terrace, ——Quarry.
Jordan Building, —— Quarry.
Pope Mfg. Co.'s Building, —— Quarry.
Tremont Temple Building, P., M. & B. Quarry.
Worthington Building, P., M. & B. Quarry.
Haverhill—P. O. Building, Peerless Quarry.
New Bedford—New Bedford Institute for Savings, Consolidated Stone Company's Quarry.
Worcester—Worcester Savings Bank Building, Consolidated Stone Company's Quarry.

MICHIGAN.

Detroit—Col. H. Hecker's residence, Thornton's Quarry.
U. S. P. O. Building, —— Quarry.
Grand Rapids—Court House, Perry's Quarry.
Jackson—U. S. P. O. Building, —— Quarry.

MINNESOTA.

Duluth—U. S. P. O. Building, —— Quarry.

MISSOURI.

Columbia—State University Building, —— Quarry.
Springfield—P. O. Building, P., M. & B. Quarry.
St. Louis—Catholic Cathedral, Grand Avenue, Reed's Bedford Quarry.
Miller residence, Reed's Bedford Quarry.
Public School Building, Star Quarry.
St. Vincent's Hospital, Peerless Quarry.
Union Depot, Tanyard Quarry.

NEW JERSEY.

Jersey City—City Hall, Hoosier Quarry, L. H. Broome, architect.
Morristown—First Presbyterian Church, P., M. & B. Quarry.
Newark—Bonnell Building, Bedford, Ind., Quarry.
Prudential Building, and Postoffice and Custom-house, —— Quarry.
Patterson—City Hall, Hoosier Quarry, Carrere & Hastings, architects.
Trenton—State Capitol, Salem-Bedford Quarry.

NEW YORK.

Albany—Col. Wm. G. Rice's residence, P., M. & B. Quarry.
Brooklyn—National City Bank Building, P., M. & B. Quarry.
N. Y. & N. J. Telephone Building, Bedford, Ind., Quarry.
Franklin Trust Company Building, —— Quarry.
Star Theatre, P., M. & B. Quarry.
Buffalo—Avery Building, —— Quarry.
Cortland—Wickwire Mansion, Hoosier Quarry. Samuel B. Reed, architect.
New York City—Eighty per cent. of buildings now going up in New York are of Indiana oölitic. [Coughlin.]
Abbey's Theatre, Broadway and 38th Street, Hoosier and Buff Ridge Quarries. J. B. McElfatrick, architect.
American Society of Fine Arts, 57th Street, between 7th Avenue and Broadway, Hoosier and Buff Ridge Quarries. J. H. Hardenbergh, architect.
Astor Residence, 5th Avenue and 56th Street, Bedford, Ind., Quarry.
Ayers Estate Building, Lispenard Street, Hoosier and Buff Ridge Quarries. Cady, Berg & See, architects.
Bank of America Building, Hallowell Quarry.
Broadway Cable Power House, Broadway and Huston Streets, Hoosier and Buff Ridge Quarries. McKim, Mead & White, architects.
Brower House, Broadway and 28th Streets, Hoosier and Buff Ridge Quarries, Alfred Zucker, architect.
Buek Block, 87th Street, between 8th and 9th Avenues, Hoosier and Buff Ridge Quarries, Charles Buck, architect.
Candee Block, 60th Street, between 5th and Madison Avenues, Hoosier and Buff Ridge Quarries, John H. Duncan, architect.
Church of St. Mary the Virgin, 46th and 47th Streets, between 6th and 7th Avenues, Hoosier and Buff Ridge Quarries, N. LeBrun & Sons, architects.
Coffee Exchange, P., M. & B. and Reed's Oölitic Quarries.

Colby residence, 69th Street and 5th Avenue, Bedford, Ind., Quarry.

Columbia College, Natural Science Hall and Hall of Physics, Morningside Heights, Bedford, Ind., Quarry. Two buildings, Hallowell Quarry. One of these buildings contains 300 carloads of oölitic limestone.

New York Commercial Building (front), C. S. Norton Quarry.

Constable Building, 5th Avenue and 18th Street, Hoosier and Buff Ridge Quarries, W. H. Schiskel & Co., architects.

Corn Exchange Bank Building, Nassau and Beaver Streets, Hoosier and Buff Ridge Quarries, R. H. Robertson, architect.

Curtis Building, South Williams Street, Bedford, Ind., Quarry.

Cutting residence, 88th Street, between 2d and 3d Avenues, Bedford, Ind., Quarry.

Deever's mansions, Manhattan Square, N., Hoosier and Buff Ridge Quarries, Berg & Clark, architects.

D., L. & W. Railway Building, Hallowell Quarry.

Dommerich residence, 75th Street, between West End Avenue and Riverside Drive, Hoosier Quarry, C. P. H. Gilbert, architect.

Emigrant Savings Bank, Chambers Street, Hoosier and Buff Ridge Quarries, W. H. Hume, architect.

Eastman's residence, 70th Street and West End Avenue, Bedford, Ind., Quarry.

Emery residence, 68th Street and 5th Avenue, Bedford, Ind., Quarry.

Fahy's Building, Maiden Lane, Bedford, Ind., Quarry.

Farmers' Loan and Trust Company Building, Hallowell Quarry.

German Life Insurance Building, Pine and Nassau Streets, Hoosier Quarry, Lamb & Rich, architects.

Gibbes' Building, Murray Street and College Place, Bedford, Ind., Quarry.

Gorard Hotel, 44th Street, Broadway and 6th Avenue, Bedford, Ind., Quarry.

Graham Building, Duane Street, Bedford, Ind., Quarry.

Graham Hotel, Madison Avenue and 89th Street, Hoosier and Buff Ridge Quarries, Thomas Graham, architect.

Herald Building, Norton's Quarry.

Dr. Herter's residence, 68th Street and Madison Avenue, Bedford, Ind., Quarry.

Hoffman House, Broadway and 25th Street, Hoosier, Buff Ridge and Robin Roost Quarries, Alfred Zucker, architect.

Dean Hoofman's Residence, 73d Street, west of 8th Avenue, Hoosier and Buff Ridge Quarries, J. B. Suook & Sons, architects.

Hotel Majestic, Central Park, W., and 71st to 72d Streets, Hoosier and Buff Ridge Quarries, Alfred Zucker, architect.

Hoyt Residence, 75th Street, between 5th and Madison Avenues, Hoosier and Buff Ridge Quarries, Richard M. Hunt, architect.

Hoyt Residence, 75th Street, between West End Avenue and Riverside Drive, Hoosier Quarry, Babb, Cook & Willard, architects.

C. P. Huntington's Residence, Blue Hole Quarry.

Lamb & Rich Block, West End Avenue and 76th Street, Hoosier and Buff Ridge Quarries, Lamb & Rich, architects.

London & Lancashire Fire Insurance Co. Building, Williams Street, Hoosier and Buff Ridge Quarries, H. J. Hardenbergh, architect.

Mail and Express Building, Broadway and Fulton Streets, Bedford, Ind., Quarry.

Manhattan Hotel, Madison Avenue and 42d Street, Hoosier and Buff Ridge Quarries, H. J. Hardenbergh, architect.

Manhattan Life Building, 66 Broadway, P., M. & B. Quarry.

McAdams Residence, 131 West 122d Street, P., M. & B. Quarry.

Mercantile Building Co.'s Block, northwest corner West End Avenue and 77th Street, Hoosier Quarry.

Mercantile Building Company's Block, West End Avenue and 78th Street, Hoosier Quarry.

Mercantile Building Company's Block, West End Avenue and 93d Street, Hoosier Quarry, Little & O'Connor, architects.

Mercantile Building Company's Block, southeast corner West End Avenue and 77th Street, Hoosier Quarry, Clarence True, architect.

Merchants' Bank Building, Hallowell Quarry.

Merritt residences (five), Riverside Drive and 91st Street, Hoosier and Buff Ridge Quarries, Little & O'Connor, architects.

Metropolitan Apartment Building, Boulevard and 88th Street, Hoosier and Buff Ridge Quarries, Little & O'Connor, architects.

Mills Lodging House, Bleecker, Sullivan and Thompson's Streets, Bedford (Ind.) Quarry.

Mt. Olivet Church, 2d Street and 2d Avenue, Hoosier and Buff Ridge Quarries, Cady, Berg & Lee, architects.

Mutual Life Insurance Company's Building, Hallowell Quarry.

Mutual Reserve Fund Life Insurance Company's Building, Broadway and Duane Street, Hoosier Quarry, W. H. Hume & Son, architects.

Office Building, corner 8th Street and Broadway, C. S. Norton Quarry.

Office Building, northwest corner 12th Street and Broadway, C. S. Norton Quarry.

Office Building, northeast corner Prince and Broadway, C. S. Norton Quarry.

Ogden Mansion, Madison Avenue and 39th Street, Hoosier and Buff Ridge Quarry, Peabody & Stearns, architects.

The Overlook Building, Corlears Hook Park, Bedford, Ind., Quarry.

Platt Block, West End Avenue, 83d to 84th Streets, Hoosier and Buff Ridge Quarries, Clarence True, architect.

Postal Telegraph Company Building, Broadway and Murray Streets, Hoosier and Buff Ridge Quarries, George Ed. Harding & Gooch, architects.

Presbyterian Building, 5th Avenue and 20th Street, Buff Ridge and Hoosier Quarries, J. B. Baker, architect.

Puritan Apartment House, West End Avenue, Boulevard, 81st and 82d Streets, Hoosier and Buff Ridge Quarries, Little & O'Connor, architects.

Public School Buildings, 82d Street and West End Avenue, Bedford, Ind., Quarry; 88th Street, between 2d and 3d Avenues, Bedford, Ind., Quarry; 119th Street and Madison Avenue, Bedford, Ind., Quarry; 88th Street and Lexington Avenue, Bedford, Ind., Quarry; St. Ann's Avenue, Bedford, Ind., Quarry; 134 Lenox Avenue, P., M. & B. Quarry; 68th Street, 93d Street and Ridge Street Schools, Quarry.

St. Andrew's Church, 76th Street, between 9th and 10th Avenues, Hoosier and Buff Ridge Quarries, Cady, Berg & See, architects.

St. Ignatius R. C. Church, 84th Street and Park Avenue, Hoosier and Buff Ridge Quarries, W. H. Schickel & Co., architects.

St. Paul Building, southeast corner Broadway and Avenue Street (26 stories), C. S. Norton Quarry.

San Reno Hotel, 74th and 75th Streets and 8th Avenue, Bedford, Ind., Quarry.

Hotel Savoy, Terre Haute Quarry.

Scotch Church, 96th Street and 8th Avenue; Scotch Church lecture room, 95th Street and 8th Avenue, Hoosier and Buff Ridge Quarries, W. H. Hume & Son, architects.

Schermerhorn Building, 23d Street, between 5th and 6th Avenues, Hoosier and Buff Ridge Quarries, H. J. Hardenbergh, architect.

Sherry Hotel, corner 5th Avenue and 44th Street, C. S. Norton Quarry.

Sloane Mansion, 72d Street, east of 5th Avenue, Hoosier and Buff Ridge Quarries, Carrere & Hastings, architects.

Mrs. Josephine Smith's residence, C. S. Norton Quarry.

Smith, Gray & Co. Building, Broadway and 31st Street, Hoosier and Buff Ridge Quarries, Buckman & Deisle, architects.

Syndicate Building, Nassau and Liberty Streets. Hoosier and Buff Ridge Quarries, Lamb & Rich, architects.

Temple Beth Synagogue, Reed's Oölitic Quarry.

Thompson Residence, 41st Street and Madison Avenue, Bedford, Ind., Quarry.

University Building, Washington Square, East and Washington Place, Hoosier and Buff Ridge Quarries, Alfred Zucker, architect.

Cornelius Vanderbilt residence, northwest corner 5th Avenue and 57th Street (large carved pilasters of), C. S. Norton Quarry, (main body of), Blue Hole Quarry.

Vanderbilt Residence, 5th Avenue, Blue Hole Quarry.

Mrs. W. K. Vanderbilt residence, Madison Avenue and 72d Street, Hoosier and Buff Ridge Quarries, McKim, Mead & White, architects.

Woodbridge Building, Williams, Platt and John Streets, Bedford Ind., Quarry.

Western Union Telegraph Building, —— Quarry.

Y. M. C. A. Building, 56th and 57th streets and 8th Avenue, Bedford Indiana Quarry.

The following buildings said to have Indiana limestone, but the quarry not known: The Wilkes, Smith, Stokes, Havemeyer, Decker Bros,, Lincoln and Colonial Club buildings, Harlan Library, Holland House, Camden Block, College of Pharmacy, Fuller Building, and about 200 residences.

Scarborough—Memorial Church, Hoosier Quarry, Haydel & Shepard, architects.

Shepard Mansion, Hoosier Quarry, McKim, Mead & White, architects.

Staten Island—Kuhnhardt Memorial Tomb, Bedford Indiana Quarry.

Syracuse—Onondaga Savings Bank Building, Consolidated Stone Co.

NORTH CAROLINA.

Biltmore—Geo. W. Vanderbilt's Residence, Hallowell Quarry.

Charlotte—United States Court House and Postoffice, ——— Quarry.

OHIO.

Cincinnati—Hamilton County House, Salem-Bedford Quarry.

The following are some of the buildings in Cincinnati in which the Bedford oölitic stone has been used, but the quarry is not known: Dennison Hotel, The Fleischman, Armstrong, Auskamp, Jos. Smith, George A. Smith, Smith's Office Buildings, and 60 or more residences.

Columbus—Commercial Club Building, Reed's Bedford Quarry.

Sidney—John Laughlin's Residence, Thornton Quarry.

PENNSYLVANIA.

Bloomsburg—M. E. Church, Thornton's Quarry.
Bryn Mawr—College Hall, P., M. & B. Quarry.
James F. Sinnott's Residence, Hoosier Quarry, Hazelhurst & Huckel, architects.
Fern Rock—Sydney D. Fisher's Residence, P., M. & B. Quarry.
Glenside—W. H. Harrison's Residence, P., M. & B. Quarry.
Harrisburg—State Library, entire, ——— Quarry.
Lancaster—St. John's Lutheran Church, P., M. & B. Quarry.
U. S. Government Building, ——— Quarry.
Merion—Lincoln Godfrey's Residence, P., M. & B. Quarry.
Newtown—The George School, (trimmings), P., M. & B. Quarry.
Philadelphia—Manufacturers' Club Building, Hoosier Quarry, Hazelhurst & Huckel, architects.
Maternity Hospital, P., M. & B. Quarry.
Tioga Baptist Church, P., M. & B. Quarry.
Reading—J. H. Sternbergh's Residence (trimmings only), P., M. & B. Quarry.
Scranton—Public School Building, Adams Quarry.
Upton—Dr. J. M. DaCosta's residence, P., M. & B. Quarry.

RHODE ISLAND.

Newport—Robert Goeblet's residence, Blue Hole Quarry.

TENNESSEE.

Lebanon—Cumberland University, Thornton's Quarry.
Memphis—Cotton Exchange Building, Griswold's Quarry.
Morristown—Normal Academy, Thornton's Quarry.

TEXAS.

Beaumont—Court House, Thornton's Quarry.
El Paso—U. S. Court House and Postoffice, ——— Quarry.
Richmond—Court House, Thornton's Quarry.

VIRGINIA.

Roanoke—Postoffice Building, Salem Bedford Quarry.
N. & W. Railway Offices, Consolidated Stone Company.

WISCONSIN.

La Crosse—Batavian Bank, Blue Hole Quarry.
Milwaukee—Gaul & Frank Building, Consolidated Stone Company's Quarries.
Winona—U. S. Postoffice Building, ——— Quarry.
Milwaukee—Germania Building, Consolidated Stone Company's Quarries.
Public Library, Consolidated Stone Company's Quarries.

VENEZUELA, SOUTH AMERICA.

Caracas—Base of General Bolivar's statue, Thornton's Quarry.

BRIDGES.

Following are a few of the many bridges of Bedford stone.

Missouri River—Bellefontaine Bluffs, Mo.; cost, $1,500,000; Geo. S. Morrison, engineer; Romona Quarry, 8,000 cubic yards.

Mississippi River—Alton, Ill.; cost, $1,250,000; G. S. Morrison, engineer; Romona Quarry, 10,000 cubic yards.

Ohio River—Cincinnati, O.; cost, $1,250,000; M. J. Becker, engineer; Romona Quarry, 9,000 cubic yards.

Chicago River—Twenty-six city bridges over Chicago River. Metropolitan Elevated Railroad river bridge.

Van Buren Street Cable Railroad Tunnel; cost, $1,000,000; 3,000 cubic yards stone; C. S. Artingstall, engineer.

Three Chicago Water Works Cribs, four miles out in Lake Michigan.

Many bridges on the Illinois Central Railroad. Many bridges on other railroads in Indiana, Illinois and Missouri. All the above from the Romona quarries. There are many others from other quarries, such as one at St. Louis and one at Memphis over the Mississippi and the Ohio River at Henderson, Ky., Cairo, Ill., and three across the Ohio at Louisville.

REPORT OF THE NATURAL GAS SUPERVISOR.

LETTER OF TRANSMITTAL.

OFFICE OF NATURAL GAS SUPERVISOR,
KOKOMO, IND., January 11, 1897.

SIR—I herewith transmit to you my second annual report, the same being the fifth annual report from this department. It is made in obedience to section 7,504 of the Revised Statutes of the State of Indiana, and is for the year ending December 31, 1896.

The purpose of the annual reports from this department, as defined by law, and an outline of this report, are given in the introductory chapter.

Again I acknowledge the cordial support that I have received from you while I have had charge of this department, and, thanking you for the same, I respectfully submit this report and remain,

Yours sincerely,

J. C. LEACH,
State Natural Gas Supervisor.

PROF. W. S. BLATCHLEY,
State Geologist.

INTRODUCTORY.

The duties of the State Natural Gas Supervisor, as defined by sections 7504–5 of the Revised Statutes of the State of Indiana, may be briefly summarized as follows:

1. To make a personal inspection, as far as it is practicable, of all the natural gas property in the State, including wells, pipe lines, machinery, etc., giving special attention to the precautions taken to insure the health and safety of workmen engaged in opening gas wells and laying mains and pipes and those who use natural gas for any purpose.
2. To collect and tabulate certain statistics regarding the geological formation, gas wells, pipe lines and manufacturing industries of the gas belt.
3. To see that all the provisions of the law pertaining to the drilling of wells and the piping and consumption of natural gas are faithfully carried out and that the penalties for the violations of the same are enforced.
4. To make an annual report to the State Geologist.

As with the duties attached to other departments of this class, the different items specified in the above summary are not alike important, and the performance of the same does not prove equally beneficial to the State; and unlike other departments, the relative importance of each class of work and the time necessary to perform the same changes with time, the age and condition of the field largely governing. The value of natural gas as a heat producing power, the past history of this gas field and its present condition certainly emphasize the fact that everything possible should be done to husband the present supply of gas. There are many ways that this can be done, and it has been to this end that my work has been directed this year. Most of my time has been spent in the field, and the information given and recommendations made are the results of observation and experiments, and not hearsay.

A brief statement of the work accomplished will be given in its appropriate connection.

The protection of the consumer and those engaged in any capacity in the natural gas industry from danger caused by carelessness or a lack of knowledge of proper methods of controlling and using this gaseous fuel seems to be the primary purpose of the law outlined in the first part of the above summary. True as this may be, however, the knowledge that this department gains, incidental to the inspection, of the condition of the field, the manner of use, and cause and extent of waste is one of the desirable as well as profitable results. It enables the supervisor to give those interested in the natural gas and manufacturing industries accurate information concerning the ever changing condition of the field and affords an opportunity to suggest economical methods of use when necessary.

The progress of the field is watched with much interest by all classes, especially those engaged in manufacturing. During the early history of natural gas in this State, but little attention was given to the condition of the field. Scientists were busy investigating phenomena attending its discovery and utilization, while residents of all occupations were busy advertising its merits. The lack of accurate and reliable information, on the part of a majority of the consumers, regarding the generation and supply of this valuable fuel, rather than a lack of knowledge of its value, or a due appreciation of the same, accounts largely for the great waste of this fuel in the past. Those who have studied the scientific phases of the question; who are familiar with the history of other gas fields and who have watched the progress of this field from year to year, know that none of these warrant waste or even extravagant use. For a number of years, to the consumer, every indication pointed to an inexhaustible supply of gas; but when the first wells began to show signs of exhaustion, attention was directed to the cause, and as a result a change was soon wrought in the popular ideas concerning these questions. The accepted theories accounting for the generation, storage, pressure, etc., of natural gas are reasonable, and these, if understood, with a knowledge of the progress of the field, will do much to prevent the prodigal use of gas that has characterized this field in the past. Then, as unfamiliar conditions arise from time to time, they should be noted, studied in the light of science and experience, and intelligently met, or we shall fail to get the full value of this reservoir of gaseous fuel that nature has given to us. For reasons that are patent, considerable space is given to this subject in this report. I know that the careful reader will learn the true condition of the field, and I trust that it will not only be of interest to those interested in this valuable industry, but will prove beneficial as well. Reference to the other subjects embraced in this part of the summary is made in the body of the report.

Full and complete statistics regarding the manufacturing industries of the State are given in the annual reports of the Bureau of Statistics and are not repeated here.

For information regarding the geological formation of the State, the reader is referred to the annual reports of the State Geologist.

The fact that many of the questions relating to the scientific phase of the subject are no longer disputed by those who have both a practical and theoretical knowledge of the same; that reasonable theories, accounting for the origin, accumulation, pressure, etc., of natural gas have long ago been discussed and accepted by the leading scientists of the country, makes a discussion of the subject at this date, a reiteration of what has been said and of very little interest to the public. It has been suggested that these conclusions are old; that they have not been added to recently. True, but is that any reason why they should be abandoned or why they are not true? Are these the only theories in the world that are old, that have not been proven false by new discoveries? Concerning natural gas, we know its nature; as to its origin all geologists agree; that the supply will finally become exhausted is not questioned any more; how long it will last is the question that has not been answered to the satisfaction of all, nor will it be. In the Twentieth Annual Report of the Department of Geology and Natural Resources, brief statements of the views accepted by the leading geologists of the country regarding the origin, accumulation and pressure of natural gas are given. All generalizations and discussions in this report are based upon the data and conclusion there given.

What the future history of natural gas in Indiana will be, depends largely upon how gas is used in the future; upon conditions attending the use of this fuel that are under the control of the gas companies and consumers. Reference will be made to this subject in a subsequent chapter.

The natural gas law of the State seeks to regulate the use and prevent the waste of natural gas; to protect from danger those who use gas for any purpose, by making it the duty of the Natural Gas Supervisor to inspect the pipe lines, regulators, etc., from time to time; to see that the proper precautions are taken to insure the health and safety of those who use it, and to condemn any line or portions of lines that are unsafe. During the early history of the field this law encountered much opposition, especially by the residents of the gas belt owning their territory and wells. Those opposed to the law contended that it abridged their rights as citizens; that natural gas is property and as such the owner has a right to use it as he desires. In opposition to this the State claims that the welfare and prosperity of the public overshadows the desire, or even good of the individual, and that the general good of all demands that a reasonable economy be practiced in the use of this gaseous fuel and if necessary, the enforcement of law to attain this is but a judicious exercise of the police powers of the State. Most opposition has been directed toward what is known as the "flambeau law," the constitutionality of which is questioned. A suit brought in Blackford County to enforce this law is now before the Supreme Court, and an early decision is expected.

I am glad to know that during the past year a great change has been wrought in the public mind on this subject. The purpose of the law is better understood and its necessity and value appreciated. The law concerning the sinking, safety, maintenance, use and operation of natural gas and oil wells and the inspection and condemnation of unsafe pipe lines and natural gas machinery is being executed and has the support of all interested.

Referring to the annual reports of this department, it has not been found possible in the past, both for want of time and space to report on all subjects indicated above in any one annual report. This would not be profitable, even if practicable. Of necessity, a large part of the Supervisor's time must be spent in the field; hence a report from this department can be little more than a record of the field work. However, in this report I have endeavored to give some space to the most important of those subjects demanding attention at present. During the year I have received a large number of letters requesting information and advice. A careful reading of this report will, I trust, render more intelligent the answers that I have given.

ACKNOWLEDGMENTS.

I take this opportunity to express my indebtedness to all who have rendered me assistance in my work. Wherever my official duties have brought me in contact with owner or managers of gas plants, manufacturers, farmers or drillers, they have been uniform in their kindness to me, giving me all the information possible and assistance desired. Largely on account of this, my work during the past year has been pleasant and I trust profitable to the natural gas industry, and consequently to the manufacturing, commercial and other industries of the gas belt.

NATURAL GAS.

In the history of civilization nothing is more interesting than the progress mankind has made toward the subjugation and utilization of the forces of nature for human welfare, and in recent years the most important fact in this onward movement is the discovery of natural gas in commercially valuable quantities and its use as a fuel. While its presence was known and its power utilized in prehistoric time it has only been within the last few years that it has been used so extensively as to modify the course of human progress. Though the use of it is limited to a comparatively small area, its influence is felt far and wide. As a heat-producing power, it possesses extraordinary value, and its utilization as a fuel has awakened a business activity within its own territory heretofore unknown. It can be used for almost all purposes for which any other fuel is used, and for cleanliness and convenience it is not surpassed.

Natural gas is a compound of carbon and hydrogen. Its principal constituent is marsh gas, which is composed of 75 parts, by weight, carbon and 25 parts hydrogen.

A brief description of the chemical constituents of Indiana natural gas was given in my last annual report, and is not repeated here, but for convenient reference the analysis is given.

Composition of Natural Gas (Haynes).[*]

Carbon	70.25
Hydrogen	21.45
Sulphuretted hydrogen	.17
Carbonic acid	.02
Nitrogen (by difference)	7.93
Total	100.00

NATURAL GAS ROCK.

While it is a fact that natural gas has been found in nearly every country and geological formation, and that its presence in various localities has been known for centuries, it is equally true that it is only in a few favored localities, where the textural and structural condition of the rock is favorable to its storage, that it has been found and used extensively as a fuel.

The Trenton limestone, a universal formation in this State and one of the most widespread on the continent, is both the source and the reservoir for natural gas in Indiana. "While it is true that the Trenton limestone is a universal formation in this State and is a reservoir for natural gas, it is equally true that these products occupy but a limited strata of this limestone and a comparatively small area of the State. The cause of this is found in the textural and structural conditions of the gas-producing rock.

"Trenton limestone is seldom a gas rock below sixty feet from the upper surface, the gas-producing stratum ranging from five to twenty feet thick. Observation and the analysis of this rock shows that its productiveness is due to its porosity. Wherever the Trenton limestone is a gas or oil rock, it is always substantially a pure dolomite, highly crystalline and of a sufficient porosity to contain large quantities of these hydrocarbons. Its storage capacity is much greater than that of sandstones. Outside of the gas area the conditions are different. There the limestone is nearly pure and non-porous The dolomitic change has not taken place.

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[*] Twentieth Annual Report of Department of Geology and Natural Resources of State of Indiana, 1895, p. 401.

"From the above it is plain that the porosity of the Trenton limestone is due to its chemical composition, or at least connected with it. In the oil and gas area this limestone has been transformed in its upper beds, the carbonate of lime giving way in part to carbonate of magnesia."*.

In the following analysis the difference in composition of a productive and non-productive rock is illustrated. At Muncie, Indiana, the limestone contains 38.11 per cent. of carbonate of magnesia, and is a productive gas rock, while at Vernon, Indiana, it contains but a trace of carbonate of magnesia, and is a barren rock.

Composition of Trenton Limestone.†

	Muncie.	Vernon.
Carbonate of lime	51.96	85.56
Carbonate of magnesia	38.11	Trace.
Alumina and oxide of iron	3.72	.60
Siliceous residue	3.30	8.00
	97.07	94.16

THE DISCOVERY AND UTILIZATION OF NATURAL GAS.

The story of the discovery of natural gas, and the exploration that followed, with the attendant success and failure of the prospectors; the approximate location of the gas area, and its development since, have been chronicled in the annual reports from this Department, and are open history. The advantages possessed by this fuel were soon demonstrated, and fuel users were not slow to adopt it. When it became known that the Indiana natural gas field was the largest and, from all indications, the most stable of any yet discovered, the manufacturing industry of this section of the State began to grow with a rapidity unknown in the past. Old factories were enlarged, new ones built, and ere long the gas belt was the manufacturing center of the State. In 1886, when natural gas was discovered, this section of the State was devoted almost entirely to agriculture. Besides the customary flouring and saw mills, the factories were few and confined almost exclusively to the manufacture of wooden wares. To-day nearly all classes of manufacturing industries are represented. Nor are these factories temporary affairs. A majority are large and well built, employing from 300 to 1,000 people.

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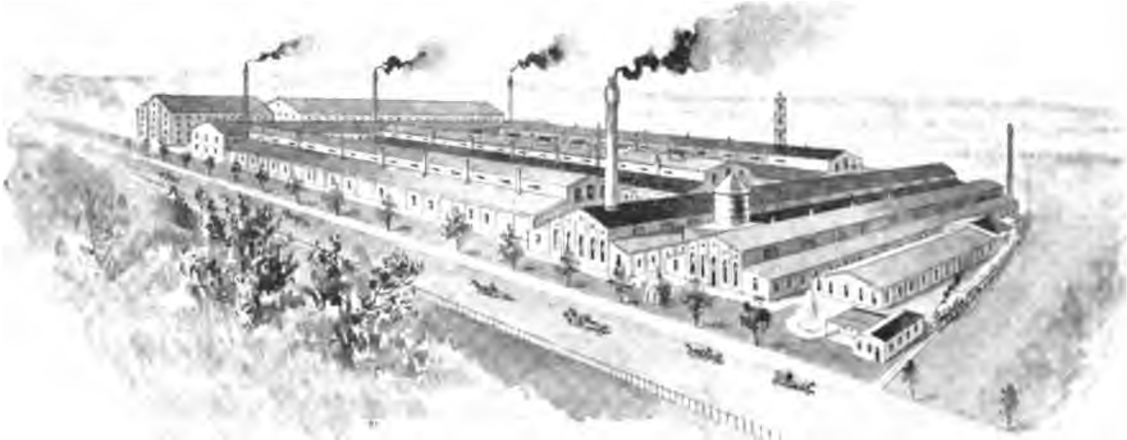
*Twentieth Annual Report of the Dept. of Geology and Natural Resources of the State of Indiana; 1895, p. 383.

†Eighth Annual Rept. U. S. Geological Survey, 1889.



Pittsburgh Plate Glass Factory, No. 8, Kokomo, Ind. Natural gas for fuel. Similar factories at Elwood and Alexandria, Madison County, Ind.

The glass industry in all its departments has increased most rapidly since the discovery of gas, caused by the perfect adaptation of this fuel to its manufacture and the superiority of the manufactured product. Nor are the tin and iron industries far behind. The tin, though a comparatively new industry, is one of the most prosperous in the gas belt. The large towns have not been the only gainers by the growth of the manufacturing industry. Factories locating in the gas belt considered transportation facilities next after cheap fuel, and many small towns being advantageously situated in regard to both, have experienced a growth not excelled by the cities. Manufacturers, however, are not the only class of people being benefited by natural gas. All classes, the merchant, farmer and laborer are its beneficiaries. Not a few farmers are receiving annually gas well rentals equal to the annual rental value of their land for farming purposes. The hundreds of wells that are being drilled and the miles of pipe-line that are being laid annually, with the labor that is necessary to properly care for the gas plants of the State, furnish work for a large number of men.

The discovery and utilization of natural gas has added materially to the wealth of the State. The natural gas property, which includes wells, pipe-lines, pumping stations, etc., is assessed for taxation at near $5,500,000. As pipe-line extensions are made and pumping stations erected this sum will be increased. The life that has been given to the manufacturing industry in this section on account of natural gas has added largely to the population and wealth of the State. The factory property alone is listed at nearly $6,000,000, and this is a small per cent. of the increase in wealth since the discovery of gas. In 1887 the total assessed valuation of the property in Madison County* was $9,837,595, which yielded a tax amounting to $168,339; in 1895 the former had increased to $26,994,775 and the latter to $397,569. This is a total increase of wealth in eight years of $17,157,180, or, exclusive of gas property and factories, $13,917,180.

The increase on account of gas property and factories is seen to be about one-fifth of the total increase. The lack of space forbids further details on this subject, but it is reasonable to believe that the same ratio holds throughout the field, with the possible exception of the outer zone.

Enough has been said to show the advance that this section of the State has made in material prosperity since the discovery of natural gas. Briefly, that discovery has added materially to the wealth of the State; it has stimulated the manufacturing industry, which in turn has added largely to our population and wealth; it has increased the farmer's income; it has reduced the fuel expense, and furnished profitable employment for thousands of men. In a word, it is a blessing to all, a proper appreciation of which would, I believe, materially extend its life.

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*Madison County is here cited because, through the courtesy of the county officials and the Board of Review, I was able to get the necessary data somewhat in detail.

In 1883 natural gas began to be used extensively as a fuel in Pittsburgh. Soon afterwards, explorations extending westward through Ohio and Indiana began in earnest. Gas was found in the Trenton limestone at Findlay, Ohio, in 1884; at Portland, Jay County, Indiana, March 14, 1886. This was the first productive well drilled in Indiana of which we have any record. Though the flow of gas was small, it stimulated the exploration in more productive territory. When it was known that the Trenton limestone in this section of the State was a gas-producing rock, companies were organized and scores of drills started. Though many failures were recorded, some were successful, and the result was that while the prospectors lost much capital and labor, the public was the gainer, for the gas belt was located and the knowledge gained from the records of the many wells drilled in all parts of the field are invaluable from a scientific standpoint. The people were not slow to learn the advantages possessed by the new fuel. The first wells were drilled at county seats, which were naturally the larger towns. Soon, however, companies were organized to supply the small towns, "farmer companies" to supply the rural districts, and every resident of the field had an opportunity to use gas. At the beginning only enough wells were drilled to supply domestic consumption, but this condition was soon changed by the location of factories and the extension of pipe lines to a number of the cities outside the gas belt. The factories, which are the large consumers of natural gas, very materially increased the draught on the territory in the vicinity of the cities and towns. Those factories that were large fuel consumers were naturally the first to locate in the gas belt, and statistics show that they are largely in the majority now. Full and complete information on the subject can be found in the Annual Reports of the Bureau of Statistics and under the head of "Manufacturing Industries" in the Report of the Eleventh Census, 1890.

PIPE-LINES.

Like the factories, pipe-line cities draw their supply from a limited territory, extending their lines from time to time as the old territory shows signs of exhaustion. The following Indiana cities, located outside of the belt, are drawing on this field for their fuel supply, to wit:

Bluffton, Connersville, Crawfordsville, Decatur, Frankfort, Ft. Wayne, Huntington, Indianapolis, Lafayette, Lebanon, Logansport, Peru, Richmond, Shelbyville, Union City, Warren and Wabash. In addition, natural gas is piped from this field to Chicago, Ill., and Buckland, Cold Water, Cridersville, Dayton, Fort Recovery, Hume, Lima, New Knoxville, Piqua, Springfield, St. Marys, Tippecanoe, Troy and Wapakoneta, O. For Chicago, the Ohio cities and towns and Indianapolis, Logansport, Lafayette and Richmond, the field pressure is re-enforced by means of compressors or pumps. With these the pressure can be raised to 300 pounds* to the square inch, which in most cases insures satisfactory service.

PRODUCTION.

It is impossible to give an accurate statement of the annual production of this field, of value of gas consumed or of number of domestic consumers. The reasons are obvious. Wells can be measured and the production ascertained for a certain period. This, however, is only the rate of production for the time the measurements were taken, for the production of a well varies, and a fair estimate of it for a given time does not indicate what it will be an hour later. It is thus seen that a measurement of all the wells would give but an approximate estimate of their annual production It is just as difficult to ascertain the consumption of natural gas in cubic feet. The methods of consumption are such that the only approximately satisfactory way of obtaining the value of the gas consumed is to ascertain the value of the fuel displaced by it. This is the basis of calculation used by the U. S. Geological Survey. From the most reliable information obtainable the Survey gives the following:[1]

"The total value of natural gas consumed in Indiana in 1895 was $5,203,200, as compared with $5,347,000 in 1894, a very slight decrease."

In the following table will be found a statement of the value of natural gas consumed in Indiana from 1886 to 1895:

Value of Natural Gas Consumed in Indiana from 1886 to 1895.[2]

Year.	Value of Gas Consumed.	Year.	Value of Gas Consumed.
1886	$300,000	1891	$3,942,500
1887	600,000	1892	4,716,000
1888	1,320,000	1893	5,718,000
1889	2,075,702	1894	5,437,000
1890	2,302,500	1895	5,203,200

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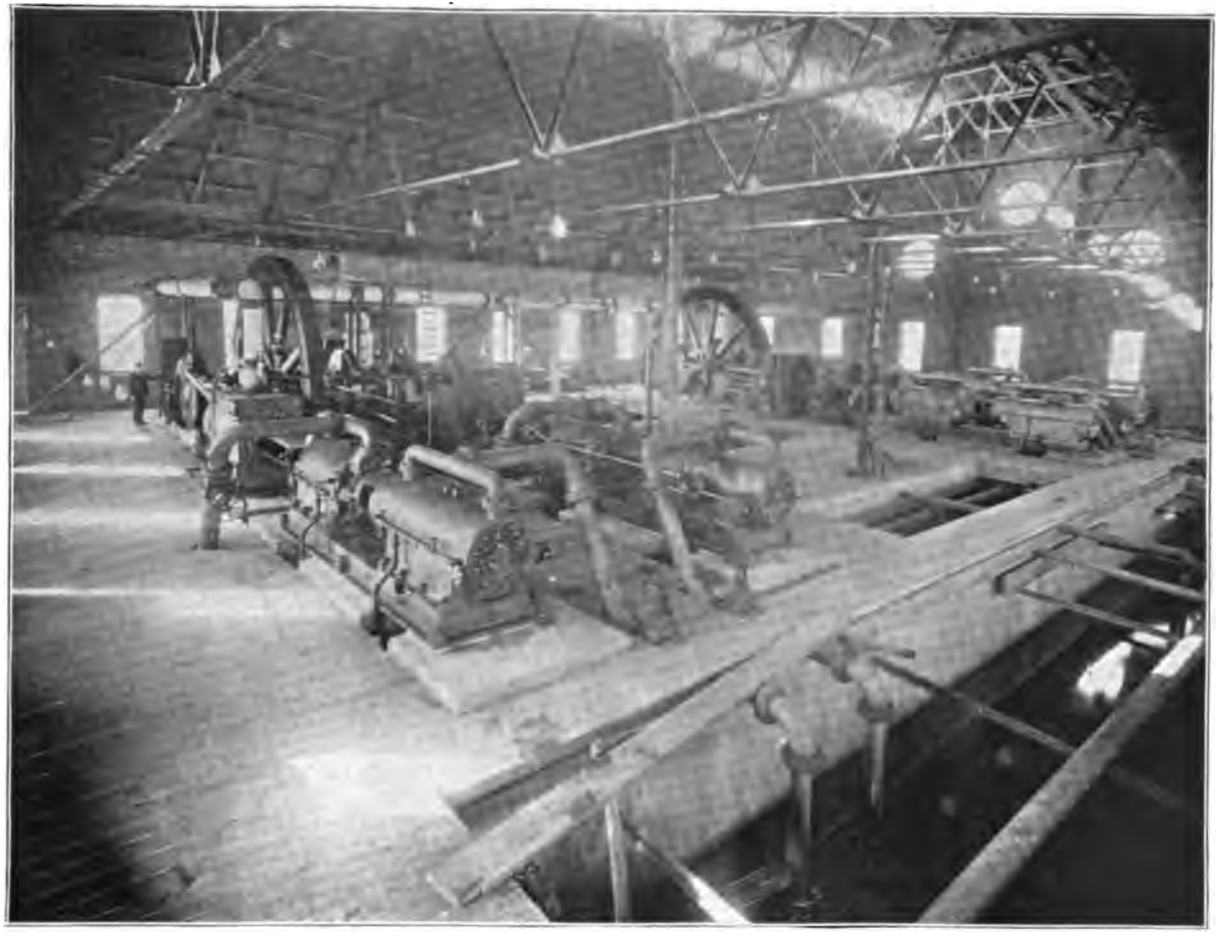
*An act passed by the General Assembly of 1891 (Acts 1891, p. 89), declares it to be unlawful to transport gas through pipes at a pressure exceeding 300 pounds per square inch, or to use any device for pumping or any artificial process or appliance for the purpose, or that shall have the effect of increasing the natural flow of natural gas from any well, or increasing or maintaining the flow of natural gas through the pipes used for conveying and transporting the gas. In the case of *Jamieson* v. *The Indiana Natural Gas and Oil Co. et al.*, 128 Indiana 555, the Supreme Court held that artificial pressure may be applied provided it does not exceed 300 pounds to the square inch.

[1] The amount of work assigned to this department precludes any time given to experiments and calculations along this line.

[2] Seventeenth Annual Report U. S. Geol. Surv., 1895-96.



MANUFACTURERS' NATURAL GAS COMPANY'S PUMPING STATION.
Interior View. Located near Frankton, Madison County, Ind.

Knowing the difficulty in obtaining full and complete information regarding these subjects, the above statements can not be more than approximate. If the reader will consider the large territory that is privileged to use this fuel for both domestic and manufacturing purposes, and that the factories are the large consumers, not a few of them requiring wells sufficient to supply towns of 3,000 inhabitants, he will gain an idea of the draught that is being made on the Indiana natural gas field.

PRESSURE.[1]

When speaking of the conditions of a natural gas field, reference is usually made to its rock pressure, many believing that accordingly as this is high or low, so is the productiveness of the field great or small. This is a mistake. While a decrease in the rock pressure indicates a general diminution in the supply, the closed pressure of a well does not indicate the volume of flow or the permanence of the supply. I have measured wells this year that registered a rock pressure of 210 pounds, and when allowed to flow unobstructed into the air did not produce one-half million cubic feet of gas in twenty-four hours, while other wells with a lower rock pressure discharged three times that amount of gas in the same time. The true index of the volume of flow of a well is the open flow pressure. True, when the rock pressure is considered with the time required to gain it, and compared with the same items of a well of known volume, an approximate estimate can be made. It is obvious that a well that shows a closed pressure of 100, 200 or 250 pounds in a minute is more productive than one that requires five or ten minutes to gain the same pressure.

From observed conditions of pressure and volume of flow in this field, the following conditions are found to be present: (1) A lack of uniformity in rock pressure; (2) a lack of uniformity in volume of flow; (3) a medium rock pressure and a small flow of gas; (4) a medium rock pressure and a productive well.

When a well is closed it becomes a part of the main reservoir, and if all the wells in the field were closed, each in time would show the same rock pressure, and the first condition given above would not exist. It does, however, and the reasons are found in the difference in the draught on certain areas, and in the texture of the rock. A gas well has reached its maximum rock pressure when the gas in it is of the same density as that in the rock. The time required to obtain this varies in different localities. When the Trenton limestone is very porous, and the gas passes freely through it into the well, the maximum rock pressure is reached quickly when the well is closed. When opened into the line the rock pressure lowers but little, and the volume of flow is large, but if the conditions are changed, a change in the result will follow. That is to say, if there is a lack of porosity in the rock and the gas passes through it slowly, it requires time for it to reach the maximum rock pressure and the capacity of the well is small.

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[1] For cause of natural gas pressure, etc., see Twentieth Annual Report of the Department of Geology and Natural Resources of the State of Indiana, 1894, pp. 384-85; also this report, pp. 44-45.

It is plain, I think, that when the draught on the well is so great that the gas does not attain the density of that in the rock before it is discharged that the rock pressure will be low, and that when the porosity of the rock permits it to pass freely to the bore, thereby permitting a heavy draught without materially lowering the density of the gas, that the rock pressure will be nearer the normal pressure of the field. Then, on account of the difference in the porosity of the rock, one well may produce but little gas, and another well in the same locality be of greater capacity; yet, whether large or small, they will, if closed, eventually reach the same rock pressure. This may require days, for, on account of the small difference in the pressure of different sections of the field, it will equalize very slowly. A well that will produce 6,000,000 cubic feet of gas in 24 hours shows no greater rock pressure than one that produces only 500,000 cubic feet, though the first reaches its maximum pressure in a few seconds, while the latter may require hours. Rock pressure does not indicate the productiveness of the field, or the condition of the supply.

Referring to this subject, Prof. Edward Orton says:* "The rock pressure of gas may perhaps be continued with little abatement of force until the end of the production of a field is near. The maintenance of pressure is no proof whatever of the maintenance of supply. The last thousand feet of gas come out from the gas-holder with as much force as the first thousand feet. In a field that contains both gas and oil, but in which the reservoir of these is differentiated, the first sign of approaching failure will be the invasion of either level by the contents of the division next below."

I have noted briefly some of the points of interest in the history of this field and outlined the conditions of the rock pressure, volume of flow, etc., that exist. With these in mind, we are better prepared to understand the present condition of the field.

CONDITION OF THE FIELD.

The Indiana natural gas field is in the eastern central part of the State and embraces the major part of seventeen counties. In shape it is an irregular obovate, its extreme length not exceeding 100 miles and its extreme width 70 miles. The original area contains about 2,500 square miles. As a whole, this is the most productive field that has yet been discovered. True, within the field an occasional "dry hole" is found. In such cases it usually happens that the rock in the vicinity of the well is too dense to permit the gas to pass through it. These barren areas are very limited, and in many cases productive wells have been obtained in close proximity to these failures.

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*Eighth Annual Report of the U. S. Geological Survey, 1889, p. 598.

By reason of the structural difference in the gas rock and the heavy draught on certain parts of the field, it can be divided into three divisions or zones, the basis of the divisions being development of territory, pressure and productiveness. This division does not take into consideration the narrow strip of territory extending south from a line running east and west through Carthage, Rush County, though southeast of this town is a fairly productive area. In the outer zone, which according to this division varies from five to fifteen miles in width, the gas rock, though productive at first, is, on account of its structural condition, its relation to the field and the long-continued and heavy draught that has been made on this part of the field, overrun with salt water. Many of the wells drilled during the early history of the field are practically worthless. Those wells that continue to produce gas and are attached to pipe-lines can only be used at periods of light consumption when a high line pressure is not required. Therein lies the danger to this territory, for it is not advisable to close wells showing signs of salt water for any length of time. There is a constant warfare between the pressure of gas and the salt water, and when the gas is held in the rock for any length of time the water accumulates in the well and will in a short time overbalance the pressure of the gas, hermetically sealing it in the rock. Wells like the above have been relieved for a time by dropping a small pipe to the bottom of the well, and the pressure of the gas, while not strong enough to raise the column of water in two or three inch tubing, will raise it through a three-quarter inch pipe. By allowing the small pipe to remain open at intervals, governed by the amount of water, the well will in most cases continue to discharge gas, more than sufficient to pay the expense of retubing. The rock pressure of this part of the field varies from 75 to 200 pounds.

The middle zone, varying in width from ten to twenty-five miles, is the principal source of the fuel supply for the pipe-line cities at present. Some of the most productive wells of the field are found here, and notwithstanding the fact that nearly all the large pipe lines pass through this territory, it lacks much of being fully developed. Hundreds of acres of good territory await the drill. Probably a majority of the wells show signs of water, but its advance so far has not been sufficient to offer much resistance to the gas. In a number of instances separators have been placed at the wells, and drips on the lines to counteract the influence of water. Concerning these I can only say that any effort made to minimize the evil influence of salt water is commendable. There are many devices designed to conduct the water from the bottom of the well, to separate the water and gas at the surface, and to catch the water that passes into the line. All have the same purpose in view, and under proper conditions show merit. Different conditions require different treatment, and meritorious devices frequently, through a lack of proper adjustment and care, fail to do the work for which they were designed. I desire to emphasize the fact here that natural gas plants need skillful, painstaking management. Not only the managers, but the men who care for the wells, pipe lines, etc., should understand the business in all its details.

While the decrease in the rock pressure during the past year throughout this area is universal, it has not been uniform. The gas in the Indiana field is entrapped in the Cincinnati arch, held there by a hydrostatic pressure equal to the weight of a column of water, the height of which is the difference in altitude between the surface of the water within the arch and the land surface of the catchment area. From this it is seen that prior to the tapping of the reservoir the gas pressure is uniform throughout the field. The lack of uniformity in pressure has been referred to in a previous section.

It was thought by those who have been watching the progress of this field that the decrease in pressure during the past year would be greater than the year previous. While the past history of the field warranted the forecast, the present condition does not fulfill it. The decrease in pressure in this part of the field during the past year is not greater than it was during the previous year, and in a few instances it is less. If pressure is governed to any extent by consumption, and it is, then the mild winter of 1895–6, the disposition on the part of the manufacturers to husband their fuel supply, and the general business depression which has affected the manufacturing industry so largely, accounts for the condition of the field. The inactivity in the natural gas industry, and the decrease in the number of wells drilled, is a consequence of the light consumption during the year. This part of the field is no exception to the general conditions found in all fields. Those areas most thoroughly developed, that contain most pipe-lines and wells, that supply the largest consumption, suffer the largest decrease in pressure. January 1, 1895, the rock pressure of this part of the field varied from 225 to 270 pounds, there being but a very few wells in and very near the large towns showing lower than the former. The average pressure of the zone was not far from 250 pounds. January 1, 1896, shows a pressure ranging from 200 to 250 pounds. While the decrease in pressure during the past year is as low as ten pounds in areas of light consumption, it has reached thirty pounds where the draught has been the heaviest. The measurements of wells in and near the large cities and towns are not considered in any of the data given.

The third zone, if it can be termed such, is the heart of the field; a region that has not been invaded by pipe lines of any considerable length. It embraces parts of Madison, Delaware and Grant Counties.* It contains, approximately, 400 square miles, and the wells that have been drilled testify to its productiveness. The upper and productive portion of the rock is free from salt water, and many wells drilled in 1887 are still producing gas. While the pressure is but little higher than that of the middle zone, it is more uniform. Recent tests show a rock pressure varying from 225 to 250 pounds. The fact that the consumption has been comparatively light during the past year has been conducive to the equalization of the field pressure, and a consequent heavy reduction of the pressure in the high pressure areas. I have said, in substance, that notwithstanding the fact that the rock pressure does not indicate the productiveness of a well, that any material reduction in it indicates a diminution in the supply. Therefore, in giving the condition of the field, I refer to it frequently. I know that it may convey a wrong impression in some instances, but it is the only way we can give the public an approximate idea of the condition of the supply of gas.

There are many erroneous ideas entertained regarding the rock pressure of this field. It is contended by some that it has not decreased a pound during the past ten years. Investigation proves that usually the fault is with the gauge used rather than an intentional exaggeration. In most cases cheap and inferior gauges are used, and, if correct when new, are soon unreliable. Gauges for this purpose should be protected from salt water or rough usage, and tested frequently to get correct results. The pressures given below are the averages of numerous tests made in each of the various localities reported, and were made with gauges made especially for the purpose and tested and corrected at frequent intervals. If there are any errors it is in the outer zone where many of the wells are not arranged so that they can be relieved of the pressure of the salt water before testing.

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*See Natural Gas map in 20th Annual Report of Department of Geological and Natural Resources of the State of Indiana, 1895.

A COMPARATIVE STATEMENT OF THE ROCK PRESSURE OF THE INDIANA NATURAL GAS FIELD, 1895-6.

	POUNDS PRESSURE.	
	1895.	1896.
Blackford County—		
Hartford City	270	240
Hartford City, five miles west of town	270	245
Delaware County—		
Muncie, three miles north of town	250	230
Royerton	250	232
Daleville, one mile west of town	225	190
Selma	230	213
Selma, three miles north of town	230	218
Albany, three miles north of town	250	230
Grant County—		
Marion, three miles southwest of town	255	244
Marion, three miles southeast of town	260	235
Jonesboro	270	250
Sweetzer	255	246
Swayzee, two miles south of town	260	250
Sims	260	245
Fairmount	270	250
Hamilton County—		
Arcadia, seven miles east of town	235	218
Noblesville, two miles north of town	200	150
Noblesville, nine miles northeast of town	235	210
Hancock County—		
Greenfield, three miles north of town	210	185
Henry County—		
Middletown, five miles east of town	220	175
Howard County—		
Greentown	255	235
Guy	255	235
Sycamore, five miles northeast of town	245	232
West Liberty	255	237
Jay County—		
Camden	150	100
Dunkirk	225	.....
Redkey, four miles southwest of town	250	235
Madison County—		
Alexandria	247	228
Alexandria, two miles west of town	255	240
Alexandria, one mile north of town	260	240
Anderson, eight miles northeast of town	240	219
Elwood	255	221
Elwood, five miles east of town	255	235
Elwood, five miles northeast of town	255	240
Frankton, two miles south of town	245	220
Gilman	256	240
Orestes	255	238
Perkinsville	230	210
Rush County—		
Carthage	150	120
Tipton County—		
Tipton	....	270
Madison Township	245	220
Prairie Township	205	.....
Wild Cat Township	250	238

GAS WELLS.

When considering a natural gas field the condition of the wells is an important item. This is an index of the condition of the field. With proper care, wells limited by unfavorable territorial conditions are frequently serviceable, while with the reverse, wells located in productive territory are sometimes rendered comparatively valueless in a short time. Referring to this field, if it is considered as a whole, it may be said that the wells are in good condition. However, a few instances have come to my notice where gas companies, manufacturers and individual owners of wells continue to attach consumers and increase the consumption of gas until the wells from overdraught, and the consequent invasion of salt water or stoppage, caused by solid particles collecting in the pores of the gas rock, are useless. Gas companies and owners of wells are fast learning that it is a mistake to turn wells into the line and pay no further attention to them until signs of exhaustion makes it necessary. A little care in estimating the gas consumed and capacity of the wells will reveal the true condition and the proper course with reference to new wells. A productive gas well is valuable property. The natural gas area and the stock of gas are limited. The reservoir has been honoring an enormous draught annually since 1887. The time of complete exhaustion is coming, and all are interested in extending the life of this valuable fuel to the farthest possible limit. To this end the wells should be examined frequently, at least once a month, during the period of heavy consumptions, and the conditions noted. The rock pressure and the pressure of the well when connected with the line should be ascertained, and from these the working pressure. This will aid in determining the necessity for new wells. If salt water makes its appearance in such quantities that it is difficult for the pressure of the gas to raise it, investigate the merits of the various devices that have been invented to separate the gas and water. If small tubing is used, the well once cleaned can be kept so by the aid of a very little gas, much less than is lost by allowing the wells to fill with salt water. When the pressure is strong enough to raise the water in the larger tubing, automatic separators placed at the wells will prevent the water from entering the line, and properly adjusted drips will counteract the evil influence of the water that from any cause has gotten into the line. While any or all of these or other devices may fail to do the work for which they were constructed, the failure often comes from the lack of proper care.

As I have said, the failure of a well may be due to a stoppage of the rock or lack of porosity in the immediate vicinity of the well. In such cases, drilling the well a few feet deeper or the explosion of a torpedo in the Trenton limestone may meet the difficulty. The former has been tried by the Elwood Natural Gas and Oil Co., of Elwood, Ind., and the latter by the Citizens' Gas Co., of Marion, Ind., and the Logansport and Wabash Valley Gas Co., Peru Division, Peru, Ind. While the results have not been uniformly beneficial, in most cases the well has been restored to usefulness for a limited period of time. One experiment by the Citizens' Gas Co., of Marion, is worth especial notice. This well is located two and one-half miles southwest of the city, in productive, though thoroughly drilled territory. It had been drilled four years and was never a large well, though the rock was penetrated the usual depth for that section of the gas belt. At the time it was "shot" it was apparently exhausted. It had been tubed with two-inch pipe, which was drawn, and sixty quarts of nitro-glycerine exploded in the gas rock. The result far exceeded the most sanguine expectations. It was necessary to retube with three-inch pipe, and one week afterward it was perfectly dry and flowing at the rate of 6,738,000 cubic feet of gas every 24 hours, an extremely large well for this territory, and in fact for this field, at this late date. This is an exceptional case. The rock is probably very dense in the immediate vicinity of the well, and the small pores that did exist were so thoroughly clogged with salt, solid members of the paraffin series, etc., that the gas could not enter the bore.

Natural gas wells must have care if we would realize their full value. If not housed, the tubing and fittings exposed should be kept painted, and the valves, etc., should be kept tight and in working order. New wells should be fitted with nipple and stop-cock, that a pressure gauge may be attached when necessary.

GAS PLANTS.

Generally speaking the gas plants in this field are in a good condition and better prepared to transport, distribute, reduce and regulate the pressure of the gas, to the safety and satisfaction of both consumer and gas company, than at any previous time. But few of the gas plants constructed in the early history of the field were planned or "put in" by practical natural gas engineers. This is especially true of the plants in the smaller towns. More than this, many were constructed hurriedly, during the winter season, and in some cases inferior piping and fitting were used. The time has been when wells in which the packers were not properly adjusted, lead-joint pipe-lines, piping too small for the work to be done, which led to a dangerously high pressure in order that the gas might be distributed, and regulators too small to regulate the pressure of the necessary amount of gas were frequently found.

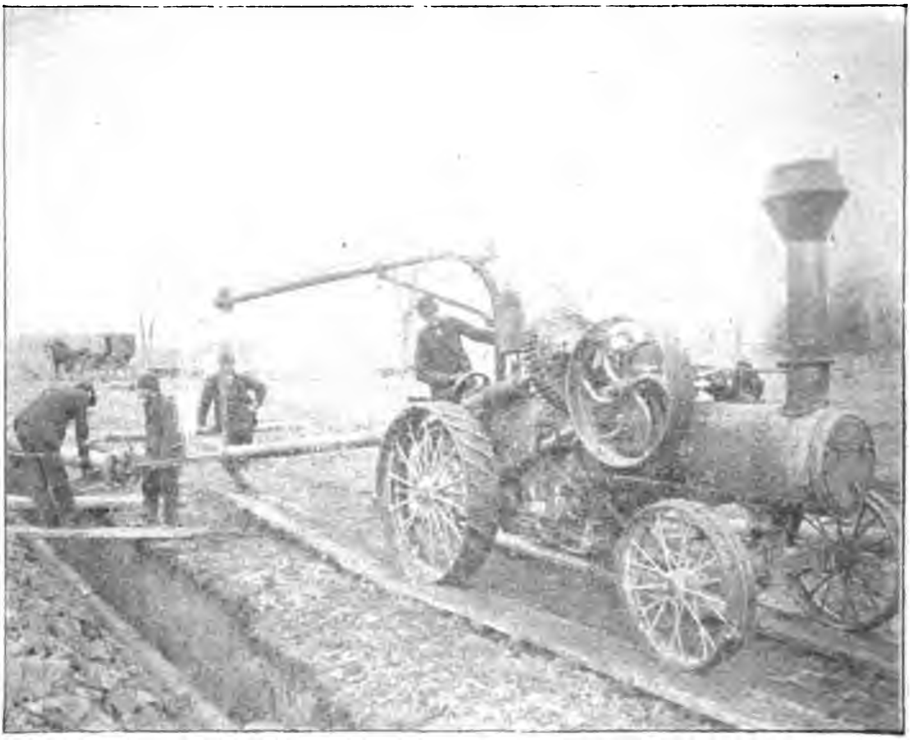
Time and necessity have forced a changed condition. A more perfect knowledge of the generation and value of natural gas, more care and skill in the adjustment of the tubing and packers in wells and the enforcement of the law regulating the "sinking, safety, maintenance, use and operation of natural gas and oil wells," have practically stopped the waste of gas at the well. True, it requires constant vigilance on the part of the Supervisor and others interested to prevent oil prospectors from allowing wells in the gas territory to stand open. All prospectors are not negligent in these matters; in fact the majority show a disposition to protect the gas territory as well as obey the law, but a few cases have been reported to this department this year wherein it seemed that the only remedy was the law. However, I am glad to say that in all these, with a little delay, the wells have been properly tubed and packed, or securely plugged, without a prosecution.

I desire to say, in this connection, that I have no disposition to antagonize or hinder the progress of the oil industry in this State, except in so far as it tends to destroy the natural gas industry. No productive oil wells have been found in high pressure gas territory. Wells drilled in this territory usually result not only in a loss to the oil prospectors, but to the gas territory as well, as they are drilled below the salt water horizon. If it is true, as it seems to be, that the major part of this field contains both gas and oil, the reservoirs of which are differentiated, and that upon the exhaustion of the gas the oil will invade its level, there is no excuse for destroying the gas territory to obtain oil.

Screwing 8-inch pipe joints by hand.

CONDITION OF PIPE-LINES.

The first pipe-line companies that entered this field seemed to do so without any definite plans or purpose, except to get gas at the least possible cost. As a result, there were many conflicting interests and much money spent without an adequate and permanent return. Two or more lines would enter the same territory, and occasionally wells were drilled, not to exceed forty feet apart. This condition has changed. Conflicting territorial interests are usually adjusted, and the condition of the field, location of the pipe-lines and wells, etc., are taken into consideration by the different companies when plans for extensions are made.



Screwing 8-inch pipe joint by machine.

With but few exceptions the pipe-lines in the State are in good condition. I have reference to the large pipe-lines. Miles of it pass through farms without the least inconvenience to the farmer, the land over and near the line being cultivated and without signs of escaping gas. A number of imperfect gates and fittings, found while inspecting new lines recently, were promptly repaired when notice was given the companies.

Pipe with the most approved joints has taken the place of some of the lead-joint pipe that was laid years ago in this field, and where the pipe has not been changed the joints have been carefully inspected, and in the majority of cases air-tight clamps placed over them. Much of this work has been done during the past year, and the various companies signify their intention to keep at the work, until every defective joint is repaired. Watchfulness and prompt action is the only remedy for this means of waste. These pipe-line leaks along the public highway are not only dangerous to the public, but are wasteful and damaging to the line, and a gas company can ill afford to allow them to go unnoticed.

Reports from every county in the gas belt show that there are near 350 natural gas companies in the State. That does not include the large numbers of factories that control their own fuel supply. A large per cent. of these are companies with one or two wells and a score or more of miles of pipe-line, varying in size from one-half to two inches in diameter. In addition to these hundreds of miles of small lines tributary to the large pipe-lines thread the gas belt, conducting gas to farm houses. These in the past have been the source of great waste. A natural gas leak, however small it is, is not only dangerous, but very damaging to the pipe. The sulphuretted hydrogen contained in the gas is absorbed by the water and oxydized by contact with air to sulphuric acid, which readily attacks the pipe, forming sulphate of iron or copperas. The above acid attacks the pipe to such a degree that it is often eaten entirely through. The gas is not the only loss. I realize how difficult it is to keep these small pipes, lying on top of the ground, subject to a varying temperature, in repair. As with the larger lines, watchfulness and prompt action is the only remedy. A number of companies keep men whose sole duty it is to keep these lines in repair. This is advisable.

As I have said, with but few exceptions, the gas plants of the State are in better condition to give satisfactory service this year, than at any time during the history of the field. I do not mean by this that the supply of gas is more abundant, but at most places it is ample and the facilities to transport and distribute were never better. In a few instances the plants if, not new, have been so thoroughly repaired that they are practically so, being much better than when first constructed, from the fact that the reconstruction has been made with reference to the work to be done. Larger regulators have been used, the necessary high lines and reducing stations have been added, and if satisfactory service is not given this winter, the fault will not be with the gas plant. Nor are the small companies alone in making improvements. The large pipe-line companies are preparing by drilling wells, extending field lines, enlarging the main service lines, and erecting pumping stations to reinforce the field pressure, to give satisfactory service.

While a gas company is largely responsible for the service rendered, it is not wholly so. The consumer is to a certain extent a party. A gas company may have an ample supply of gas and a plant practically perfect, so far as the regulation and distribution of the supply is concerned, and yet render unsatisfactory service to some of its patrons. In order to realize the full heating power of natural gas, it is necessary to mix it with air. As to the proper proportion of air to gas there is a difference of opinion; ten of air to one of gas is not far from correct. If this proportion is to be maintained the pressure of the gas should not vary, for a mixer that will admit gas and air in the correct proportion when the gas is under a twelve-ounce pressure will admit a larger amount of gas if the pressure is increased to sixteen ounces. Ninety-six cubic feet of gas under a pressure of three-tenths of a pound will pass through a No. 7 mixer in one hour, while under one pound pressure one hundred and seventy-nine cubic feet will pass through the same mixer in the same time. It is evident from the above that when a mixer is so adjusted that the gas and air are admitted in the proper proportion, the pressure of the gas should not be changed unless the amount of air admitted is changed to correspond. Referring to this subject, Prof. Elwood Haynes said in my last annual report:* "The volume of air required to burn 100 cubic feet of gas is 1,001.27, or almost exactly ten times the volume of gas consumed. In practice, however, it is advisable to use a little more air than is called for by the formula,† in order to insure perfect combustion. If, however, the mixture can be made perfect it is not advisable to admit too much air, as all surplus air tends to carry away heat which might otherwise be utilized. A good method of regulating the "quality" of a gas flame is to adjust the air supply at the mixer in such a manner that there is just a slight white tip occasionally visible at the end of the flame, and then turn on enough air to cause this to disappear.

It is obvious from the above that unless the mixer is clean and so adjusted that the gas and air are admitted in the proper proportion and a uniform pressure is maintained, that the combustion will not be perfect. The result of incomplete combustion is never satisfactory. That natural gas is used extravagantly by domestic consumers is known by every one that uses it. Its very convenience leads to this. Crude mixers and burners do not allow the full power of the gas to be realized, and with this the temperature of most dwellings is kept above the health limit. With the present system of selling gas it is difficult to change these conditions. The difficulty can be reduced to a minimum, however, if the consumer will see that all mixers and burners are clean and properly adjusted to the gas pressure, and the gas companies that the gas pressure is kept uniform at the point of comsumption.

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* Utilization of natural gas, p. 204.

† Given in same paper.

THE FUTURE OF THE INDIANA FIELD.

In so far as they serve to light the future, the present condition of the Indiana natural gas field and its past history are questions in which much interest is being manifested by all classes of consumers, as well as the gas companies of the State. All are anxious about the future of this fuel and its increased cost, caused by the drilling of new wells, the extension of pipe-lines, etc., necessary to maintain our supply, stimulates this anxiety, as well as an appreciation of its benefits. Factories, public buildings, residences and in fact all classes of buildings, built during the last ten years, in which a heating power is required, have, at more or less expense, been fitted for gas. And while the return to wood or coal would cause great inconvenience in the way of changes and the remodeling of heating apparatus, it is not beyond a future possibility. Nearly all agree that the supply will finally be exhausted, but when, is the question. We can examine this field under the light of the finished history of the Findlay field, but when we consider the conditions and limitations surrounding it and not found in this field, and *vice versa*, we at once see that an answer based upon the most trustworthy data obtainable is little more than a guess. Those who have ventured an answer have been compelled to revise it from time to time, as unforeseen conditions arise. It can not be said, however, that because the life of natural gas is a subject of speculation, that all phases of the question are thus. Science has settled some questions beyond a doubt. That natural gas has its origin through the decomposition of organic matter contained in the rocks; that it is a stored product, and that nature has made no provision for a renewal of the supply, are conclusions that are not questioned by students of the subject.

The life of this field, then, is to be determined by the extent of the reservoir, or supply of gas, and consumption. Regarding the former, its capacity has not been determined, nor can it be. The porous rock forming the reservoir is known to be but a few inches thick in some localities, while in others it varies from twenty to thirty feet. We have no means of estimating the capacity of this irregular mass of gas rock. Referring to this subject, Prof. S. S. Gorby, Ex-State Geologist, says:* "Confined within its reservoir of rock, the gas is compressed to an enormous extent. There is no means of determining the capacity of the interstices of a cubic foot of porous rock that forms the gas reservoir. When the exact limits of the gas area are known, and when the average thickness of the rock is known, the capacity of a gas reservoir may be estimated to an approximate degree, but it will never be possible to estimate to any satisfactory extent the capacity of the interstices that contain the gas. If it was known just how many cubic inches of gas in its compressed state there are in a cubic foot of porous rock, and if it was known, too, just how many cubic feet of gas those cubic inches are equal to, reduced to atmospheric pressure, then we could determine approximately how many thousand million of cubic feet of gas there are in a reservoir."

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*Sixteenth Annual Report of the Dept. of Geology and Natural Resources of Indiana, 1888, p. 200.

If we do not know the extent of the reservoir or amount of gas stored therein, and do know that there is a definite limited stock, then the future of the field is uncertain, and will be governed by the way it is used.

Professor Edward Orton refers to the subject as follows:* "That the gas and the oil are stored products, accumulated in rocks of suitable structure to serve as reservoirs, or, in other words, that we are drawing upon a definite stock of this substance, is the only rational view to be taken of the facts involved. There was in the Findlay field originally a vast but still not an incalculable amount of gas, either dry or held in and permeating the oil that accompanies it. Upon this stock the wells are drawing. From it a given number of millions of cubic feet can be used for a given number of years, but when once exhausted there is no more possibility of its renewal in the reservoir than there is of the growth of coal in mines that have been worked out. It is in this light that the waste of these priceless accumulations ought to be regarded."

From what has been said the duty of every gas company, consumer and person employed in the natural gas industry is plain. If the life of this gaseous fuel depends upon the way it is used, then let us practice an economy commensurate with its value, and stop all waste. Notwithstanding the extravagant use and vandal-like waste in the past, no one will deny that much can be done to extend the life of gas by a strict observation of the above in the future.

Those not familiar with the gas field probably consider it a waste of time and space for me to argue at this time the necessity of husbanding the supply of gas; and, true, it seems reasonable to suppose that every one interested would see the necessity of it, and govern himself accordingly. I am sorry to say that such is not the case. While the constant agitation of the matter in the published reports from this department, and the personal efforts made by the Supervisor and other interested parties who know the necessity and importance of prompt action has done much good, there is still room for a vast improvement.

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* Eighth Annual Report of the United States Geological Survey, 1889, p. 612.

In so far as natural gas has stimulated the manufacturing industry, and influenced capital to invest in this State, thereby increasing the wealth of the State, it has benefited every taxpayer and citizen. Those most directly interested, however, are residents of the gas belt, gas companies, manufacturers, farmers, laborers and domestic consumers. It is to these we must look for aid in husbanding the supply of gas, and in creating a public sentiment against the prodigal use of it.

Gas companies can do much toward protecting the natural gas industry, not only by preventing waste at the wells, along the line, etc., but by inspecting the burners, mixers and other devices used by their consumers and suggesting such changes in the same as economy and safety require; also, by properly regulating the pressure of the gas at the point of consumption, to the end that the maximum amount of heat may be obtained from the gas used.

It would not be just to say that all manufacturers use natural gas extravagantly, but an examination will convince any one that a majority use more for both fuel and light than is necessary. In many instances the burners, mixers, etc., are so unscientific and ill-arranged that perfect combustion is not possible. The full heating power of the gas is not realized and more fuel is used than would otherwise be necessary.

Natural gas as an illuminant is not a success. It produces a very poor light, and when its value as a fuel and the amount of gas necessary to make even a passable light is considered, it is expensive. Many of the larger manufacturers, realizing this, are substituting other light for it. That it is convenient for this purpose, when used as a fuel, is the most that can be said in its favor. If it is used, however, I am sure that it is quite unnecessary and wasteful to allow large torches to burn night and day in all departments of the factory, whether operating or not.

As I have said all manufacturers are not wasteful in using this gaseous fuel. There are a few, and the number is increasing, that fully appreciate its value and use it accordingly. I have visited a large number of factories this year, and all suggestions made by me regarding the economical use of gas have been received in the same spirit in which they were given, and in most cases acted upon. It is my purpose to visit all the factories using gas as soon as my duties will permit.

If it could have been possible for us to keep the enormous fuel supply that was stored in the rock underlying this section of the State within the borders of the gas belt, the result would be far different from what it will be, judging from present indications. It is impossible to place the limit on the time for which the supply would have been adequate for the local consumption, but cities in adjoining territory, knowing the advantages possessed by it, organized companies and invaded the field; and while the result will be a comparatively speedy exhaustion of the field, it will also be a speedy remuneration to the land owner for the rights and privileges granted the gas companies. During the past year the expenses of the various gas companies on account of rentals, gas privileges, labor, etc., was above $550,000. Of this amount about $300,000 was paid direct to the farmers. This does not include cost of pumping stations or office expenses of the larger companies. It is plain that the residents of cities are not the only beneficiaries of the natural gas industry. Many land owners are receiving annual gas well rentals equal to two and one-half dollars per acre for their entire farm, and some are receiving five, that is, $400 annually from an eighty acre farm. In addition to the above, free gas for domestic purposes is usually included in the lease.

Taking into consideration the fact that the natural gas industry does not interfere with the use of the land for farming purposes in the least, there seems to be good reasons why farmers should aid the efforts that are being made to prevent such waste in the future as has been allowed in the past. When by care and extra expense the life of a well is extended one year, the landowner is a beneficiary to the extent of the annual rental. It is from this standpoint and the general welfare of the gas belt and State that the farmer should consider all efforts to husband the gas supply.

Of the three classes of natural gas consumers; pipe-line cities, fac tories and local domestic, the former will first feel the exhaustion of the field. When gas has to pass through a considerable amount of pipe before it reaches the consumer, the initial pressure is an important item. It is affected by friction against the walls of the pipe in the same manner as is water or any other liquids. The loss in pressure is goverened by the size of the pipe, length of line, velocity of flow, condition of the gas, etc. Added to the above there is often an unnecessary loss of pressure by reason of numerous bends and elbows in the pipe and leakage. By removing, as far as possible, these unnecessary conditions, the loss will be reduced to a minimum; but even then the back pressure in the pipe will finally overcome the initial pressure. Under the most favorable conditions, the distance that natural gas can be piped is limited, unless pumps be used. While the loss of pressure by friction in any given line can be ascertained if all the conditions are known, they are so many and varied in this field and the effect of each is so difficult to ascertain that results of calculations on the subject are not very satisfactory. Each line is surrounded by conditions differing to some extent from those of any other line, and the loss of pressure in a given line does not indicate what it is in other lines of similar dimensions. Examinations of a number of lines show that the loss of pressure during the period of heaviest consumption is from two to six pounds to the mile, owing to the consumption along the route of the line and the other conditions referred to above.

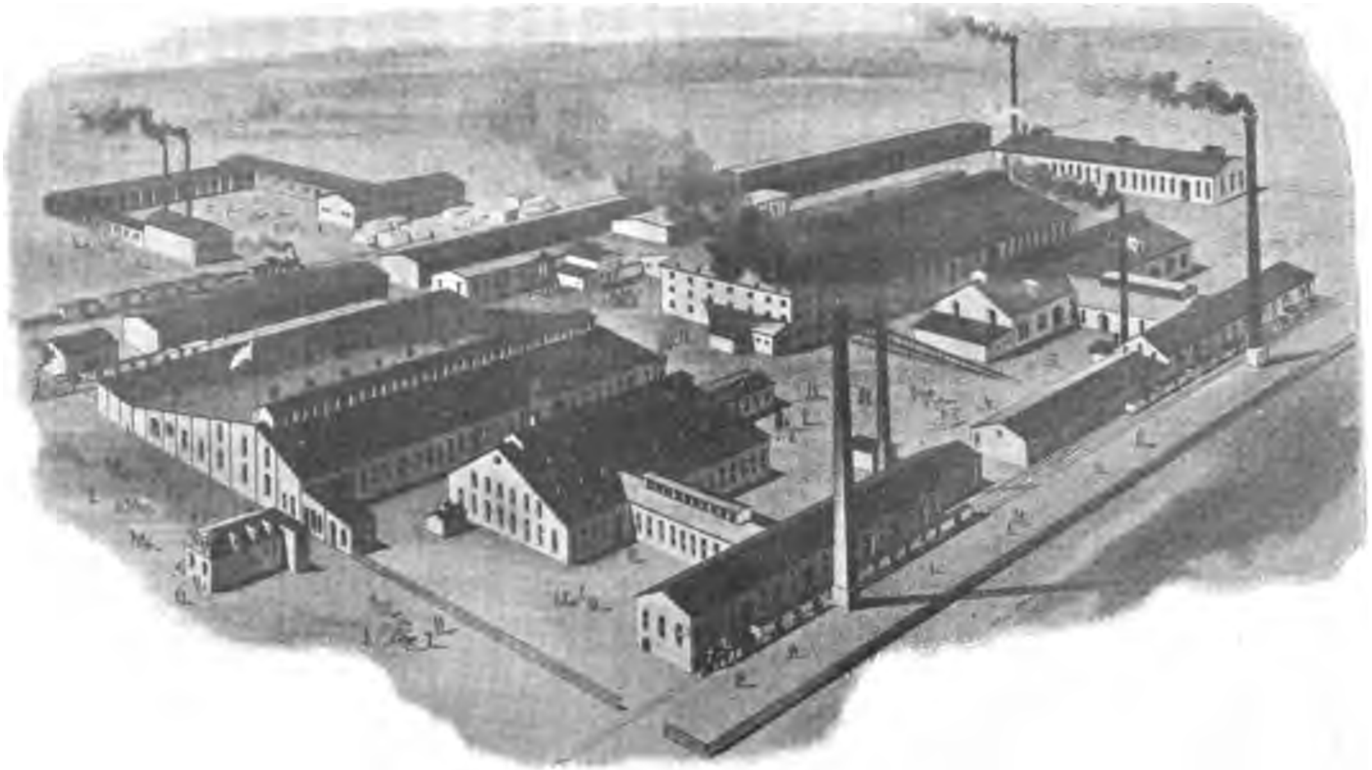
THE MANUFACTURING INTERESTS OF THE GAS BELT.

For reasons previously stated, the gas belt has become the manufacturing center of the State, and the many evidences of a decrease in the gas supply naturally encourages speculation regarding the future of these industries. While every taxpayer is interested in this question, residents of the gas belt are especially so. A sufficient cause for this is found in the increase of wealth and volume of business in this section of the State since the discovery of gas. I have endeavored during the past year to familiarize myself with the condition of the fuel supply of the factories located in the gas belt on account of natural gas. While a change of fuel will be necessary in the future, and no person knows this better than the manufacturers, there is no cause for immediate alarm. Manufacturers know and appreciate the value of natural gas, and are providing for the future as far as possible. The larger factories, located near cities where the field shows signs of exhaustion, have pipe lines and sufficient territory to protect their interests. Others located where the consumption for other purposes is light are drawing from wells in the vicinity of the factory; two hundred feet of pipe in some instances being sufficient. True, a majority of the first wells drilled show signs of exhaustion, but in many cases the territory is only partially developed, and the new wells are usually productive. Any signs of a shortage in the fuel supply causes much anxiety regarding its future on the part of the manufacturers, and this is usually followed by more care and economy in its use. Further inquiry shows that other fuels can be used, without serious inconvenience, to supplement the supply of gas where it fails to come to the full requirements of the manufacturing plants.

Of course the chief reason for the location of factories in this section of the State during the last nine years are the advantages possessed by this fuel, but evidence is present that the proximity to the markets of the country and the splendid railroad facilities possessed by this section were considered. And, while it is true that some manufacturers who have outlived a less productive gas field are apprehensive concerning the future, they are disposed to find another fuel in case it is necessary, rather than a new location. Taking into consideration the present condition of the field, the proximity to the Indiana coal field and its railroad connection with the gas field, it seems that a majority of the manufacturing industries of the gas belt are permanently located.

The gas used for domestic purposes is a small per cent. of the entire consumption, and for obvious reasons it will be used longer for this purpose than any other. When the supply is exhausted, so far as the larger consumers are concerned, wells apparently worthless will continue to supply gas sufficient for domestic consumption, and a redrilling of abandoned territory is not beyond the future possibilities. Fairly productive wells, though short lived when turned into a factory line, have been found in abandoned territory. Doubtless they would have been more satisfactory if used for domestic purposes only. A visit to those sections of the field where the supply has never been large, and the rock pressure is low, will convince any one that very small wells are used and appreciated where larger wells are not to be had.

The territory in which natural gas has been found is comparatively small, but its influence extends far beyond the limits of the field. Wherever the products of the gas belt factories are sold, there you will find those who are anxious about the life of this gaseous fuel. Nor is it probable that its influence will cease to be felt when the supply is exhausted; for the use of it by practical fuel consumers and the knowledge of its superiority as a heating power gained thereby, has so revolutionized the construction and arrangements of manufacturing plants and modified manufacturing methods to such an extent, that it is probable that better results will be obtained from other fuels in the future, and it may open the way to the use of fuels heretofore not available. Natural gas is a cleanly fuel. It is economical and convenient, and its superiority as a fuel is best illustrated in the improved quality of the product of the gas belt manufactories.



Hartford City Glass Company's Factory, Hartford City, Indiana. A "gas belt" factory employing 600 men; 120 blowers; monthly pay-roll, $50,000; annual capacity, 400,000 boxes.

REPORT OF STATE INSPECTOR OF MINES FOR 1896.

PROF. W. S. BLATCHLEY,
State Geologist of Indiana:

In beginning my second annual report as Inspector of Mines for the State of Indiana I desire to return thanks to the mine officials and others whose co-operation has to some extent lightened the labors of the office and made it possible to give an approximately correct statistical report of the coal business of the State for the year just closed. I found it necessary early in the year to institute legal proceedings against several mine bosses for failure to make reports provided for in section 19 of the coal mine act of 1891. In only one case was any defense made in court. In that a conviction was secured. Other cases were disposed of without my being called upon to attend court, and I have had no further trouble in any of the counties where such proceedings were had.

While there is no statute requiring a report of tonnage or wages paid from any operator or agent, I am pleased to state that there has been a very general compliance with my requests for such information, but the early date at which this report is filed prevents me from including the returns for December herein, and I therefore omit the table showing the output of each mine. I shall supplement this report later with such a table, if I can get the returns before this goes to press. I have made an estimate of the items enumerated by statute which are to be included in this report. The figures are likely to be changed when the reports are all received, but I think the totals will be found practically correct. There is quite a decrease in the production of coal from last year. This is caused partly by the general depression in manufacturing and transportation lines, but the shortage in Indiana has been increased by the strike of bituminous miners, which began on May 1 and was not finally ended till December 1. Its effects will be noted by comparing the production of the counties of Greene, Parke, Sullivan and Vigo during the present year with that of 1895. The only other county affected by the strike was Vermillion, where the Buckeye mine was idle for a short time. The causes mentioned have reduced this year's output to 4,068,124 tons as against 4,312,084 tons in 1895, a decrease of 243,960 tons in this State, while the best figures obtainable at this date show an increased production of bituminous coal in the United States of 4,371,752 tons in a total of 141,770,099 tons.

I am pleased to be able to remark a great improvement in the condition of those mines, which have been at work during the entire year, in respect to ventilation, and a more general compliance with minor provisions of the mining law in those points that come under the observation of the Inspectors. Some statutes are practically ignored because the idea seems to be entertained that only the Inspector of Mines has the authority to prosecute for violations of their provisions. Of these I note, that requiring regular visits of mine bosses to the working places of employes, that prohibiting the leaving open of doors used to direct air currents, and that prohibiting riding on loaded cars. These may be violated daily without such violation coming to the knowledge of the Inspector unless a fatal accident occurs from such violation. Some of these could have been prevented if the law had been enforced by those in authority, and the necessity for such enforcement can not be too strongly emphasized. This is referred to at greater length in noticing accidents which have occurred during the year.

It will be noticed that there has been a large increase in the number of fatal accidents during the year under review. With but few exceptions they have arisen from the ordinary risks of the mining business. The exceptions are noted in another part of this report The increased number of serious and minor accidents reported is doubtless due to the fact that full reports were not made in former years. This is also true to some extent in the case of fatal accidents. Previous to July, 1895, reports were made from the offices of the operators, and were not as full as those since made by the persons in charge of the mines.

As many of the mines of the State were idle for fully half of the year we did not make any inspections of such during that time, and we have not found time to examine all of them since they resumed work. This has given us an opportunity to pay more attention to those which were in operation, which we have done, with good results. Mr. James Epperson, of Linton, Indiana, has been Assistant Inspector during the whole of the year, and has discharged the duties of the position to my entire satisfaction. A list of mines, with their owners and mine bosses, is given on another page, followed by a short description of each mine. For convenience I have arranged them alphabetically by counties, and the names of the owners. The table shows also the number of men employed inside of the mine, number employed outside, and the number of mules or horses used in the mines. In some instances I think that the men employed outside, as given, includes the office force, while in others it does not, but as I have no data from which to make the necessary corrections I have copied the figures as given in the latest reports. The totals given in the following summary give as nearly as can be ascertained the number of men employed in and about the mines of the State at the end of the year by counties, and the number of mines opened during the year, the number abandoned, and the number available for work, including those temporarily suspended, but which are in condition to employ ten or more men.

COUNTIES.	New Mines.	Mines Abandoned.	Mines Open.	Men Employed Inside.	Men Employed Outside.	Animals Used.
Clay	5	6	29	2,216	180	148
Daviess	1	2	10	376	44	56
Fountain	. . .	2	1	100	8	9
Gibson	1	. . .	2	62	21	3
Greene	1	. . .	7	614	52	48
Knox	. . .	. . .	3	119	16	7
Martin	1	. . .	1	17	2	1
Owen	. . .	. . .	1	52	4	2
Parke	1	1	14	816	79	50
Perry	. . .	. . .	2	55	10	7
Pike	1	. . .	5	332	40	39
Spencer	. . .	2	. . .	. . .	. . .	. . .
Sullivan	. . .	. . .	12	618	95	65
Vanderburgh	. . .	. . .	6	165	44	31
Vermillion	1	1	4	412	44	38
Vigo	5	. . .	17	348	39	25
Warrick	4	. . .	7	111	21	13
Totals	21	14	121	6,413	699	542

The large reduction in the number of men employed inside at the close of the year as compared with 1895 is due to the fact that the strike which continued in the bituminous field from May 1 well into December left many of the mines in such a state that a full complement of men could not be put to work.

TABLE SHOWING EMPLOYES AND PRODUCTION BY MONTHS.

MONTH.	Inside.	Outside.	Mules.	Days Worked.	Screened.	Slack and Nut.	Mine Run.	Total.
January	7,259	796	580	. .	260,017	91,952	93,108	445.077
February	6,669	719	569		205,114	83,874	83,640	372,628
March	6.445	688	557	. .	223,489	83,291	126,971	433.751
April	5,886	669	498	. .	200,175	84,755	132,225	417,155
May	3,835	404	339	.	51,070	20,608	60,651	132,329
June	4,130	330	333	.	79,312	27,035	89.948	196,295
July	3,937	403	318	. .	85,554	28,018	68,267	181,839
August	4,453	461	387		109,120	41,297	103,548	253,965
September	4,757	505	388	. .	141,360	58,032	101,658	301.050
October	5,111	571	459		186,490	73,753	122.029	382,272
November	6,143	614	531	. .	191,395	74,214	121.993	390,602
December	6,413	699	542	.	208,134	80,705	135,924	421,763
Small mines	. . .	. . .	.		. .		136,398	136,398
Total	. . .	. . .	. . .	. .	1,941,230	747,534	1,379,360	4,068,124

TABLE SHOWING THE ANNUAL PRODUCTION OF COAL FOR THE STATE OF INDIANA, FROM 1879 TO 1896 INCLUSIVE, AS SHOWN BY REPORTS OF MINE INSPECTORS.

YEAR.	TONS.	CAPITAL.	INSPECTOR.
Oct., 1879 to Oct., 1880	1,996,490	$1,135,562	Richards.
1881	1,771,536	1,442,210	Wilson.
1882	....	....	
1883	2,560,000	1,600,000	Wilson.
1884	Est. 2,260,000	1,750,000	Wilson.
1885	2,375,000	1,850,000	McQuade.
1886	3,000,000	1,975,000	McQuade.
1887	3,140,979	....	McQuade.
1888	....	....	
1889	3,676,000	2,081,000	McQuade.
1890	....	....	Tislow.
1891	3,819,600	(new) 185,000	McQuade.
1892	4,494,811	....	McQuade.
1893	4,358,897	....	McQuade.
1894	3,440,353	....	McQuade.
1895	4,312,084	1,852,500	Fisher.
1896	4,068,124	1,750,000	Fisher.

Table Showing the Number of Mines, Men Employed, and Estimated Capital Invested in the Coal Business in the State of Indiana, by Counties, for 1895.

CLAY COUNTY.

Number.	OWNER.	ADDRESS.	MINE.	MINE BOSS.	ADDRESS.	Employes. Inside.	Employes. Outside.	Mules.	REMARKS.
1	Brazil Block Coal Co	Brazil, Ind	B. B. No. 1	John Bolin	Brazil, Ind	121	15	11	Electric machine.
2	Brazil Block Coal Co	Brazil, Ind	Gart No. 3	Wm. Conroy	Brazil, Ind				Flooded.
3	Brazil Block Coal Co	Brazil, Ind	Gart No. 5	Andrew Gilmour	Cardonia, Ind	183	11	10	
4	Brazil Block Coal Co	Brazil, Ind	B. B. No. 6	...	...	...	...	...	Abandoned.
5	Brazil Block Coal Co	Brazil, Ind	B. B. No. 8	August Norkus	Diamond, Ind	207	19	12	Electric machine.
6	Brazil Block Coal Co	Brazil, Ind	B. B. No. 10	John Mushett	Brazil, Ind	32	3	2	Being finished.
7	Brazil Block Coal Co	Brazil, Ind	B. B. No. 11	Robt. J. Wallace	Diamond, Ind	154	13	...	New mine.
8	Brazil Block and Pav'g Co	Brazil, Ind	Brick	James Kennedy	Brazil, Ind	10	2	1	Use their own coal.
9	Brazil Mining Co	Chicago, Ill	Gladstone	M. McMarrow	Brazil, Ind	102	6	8	
10	Briar Block Coal Co.	Chicago, Ill	Briar Hill	A. L. Boore	Clay City, Ind.	14	4	1	
11	Chicago & Indiana Coal Co	Terre Haute, Ind	Harrison	Thomas Faulds	Clay City, Ind.	104	9	10	
12	Coal Bluff Mining Co	Terre Haute, Ind	Pratt	H. W. Jenkins	Coal Bluff, Ind	146	8	7	
13	Crawford Coal Co	Brazil, Ind	Pratt No. 2	Walter Knox	Ashersville, Ind.	134	7	4	
14	Crawford Coal Co	Brazil, Ind	Pratt No. 3	Wm. Penze	Hoosierville, Ind	42	3	3	New mine.
15	D. H. Davis Coal Co.	Knightsville, Ind	World's Fair	Robert Jenkins	Knightsville, Ind	38	3	3	
16	Diamond Block Coal Co.	Chicago, Ill	Dismond No. 3	Thos. McQuade	Brazil, Ind	117	12	9	
17	C. Ehrlich	Turner, Ind	Fortner	Ellsworth Tibbits	Turner, Ind	59	7	5	Bituminous.
18	C. Ehrlich & Co	Turner, Ind	Excelsior	H. B. Ehrlich	Brazil, Ind	29	4	3	
19	P. Ehrlich	Turner, Ind	Superior	...	Turner, Ind	85	6	3	
20	Eureka Block Coal Co.	Terre Haute, Ind	Eureka No. 1	...	...	...	...	...	Burned down.
21	Eureka Block Coal Co.	Terre Haute, Ind	Eureka No. 2	Thomas Dalton	Carbon, Ind	204	7	16	
22	Goucher, McAdoo & Co	Brazil, Ind	Monarch	James King	Brazil, Ind	16	1	2	Use their own coal.
23	Jackson Coal and Min. Co	Brazil, Ind	Brazil	Moses Marks	Cardonia, Ind	140	7	7	
24	Jackson Coal and Min. Co	Brazil, Ind	Nickel Plate	John Cox	Brazil, Ind	68	7	7	
25	I. McIntosh & Co	Brazil, Ind	McIntosh No. 2	W. L. Wallace	Brazil, Ind	13	2	1	Being finished.
26	Markland Coal Co.	Clay City, Ind.	Burger	...	...	...	...	...	
27	Otter Creek Coal Co	Brazil, Ind	Fairview	W. J. Price	Cardonia, Ind	103	6	8	
28	Otter Creek Coal Co	Brazil, Ind	Nellie	D. J. Evans	Brazil, Ind	17	2	2	Being finished.
29	Jos. Somers	Staunton, Ind	San Pedro	Ed. Somers	Staunton, Ind	...	...	...	Shut down.
30	Watson, Little & Co.	Chicago, Ill	Gartside	...	...	...	...	...	Abandoned.
31	Henry E. Weaver	Chicago, Ill	Louise	Griff Howels	Center Pont, Ind	50	6	6	
32	Zeller, McClellan & Co	Brazil, Ind	Briar Hill	M. Hofmann	Ashersville, Ind	73	5	5	
33	Zeller, McClellan & Co	Brazil, Ind	Columbia	...	...	...	...	...	Abandoned.
34	Zeller, McClellan & Co	Brazil, Ind	American Beauty	...	...	...	...		Abandoned.
35	Zeller, McClellan & Co	Brazil, Ind	Columbia No. 4	Thos. Thompson	Hoosierville, Ind	55	5	2	

DAVIESS COUNTY.

36	Cabel & Co.	Washington, Ind.	No. 4	Anton Kocher	Washington, Ind	106	10	18	
37	Cabel & Co.	Washington, Ind.	No. 7						Abandoned.
38	Cabel & Co.	Washington, Ind.	No. 9	Gus Wellinger	Washington, Ind	91	8	10	
39	Cabel & Co.	Washington, Ind.	Maple Valley						Abandoned.
40	Daviess County Coal Co.	Montgomery, Ind	Montgomery, No. 1	James Brown	Montgomery, Ind	75	12	13	
41	Daviess County Coal Co.	Montgomery, Ind	Montgomery, No. 2	Geo. B. Brown	Montgomery, Ind				Suspended.
42	Mutual Mining Co.	Cannelburg, Ind.	Mutual	M. Cahill	Cannelburg, Ind.	48	9	3	
43	Odon Coal Co	Odon, Ind	Winkelpleck			7			
44	A. F. Stoy & Son	Odon, Ind	Stoy	Oliver Herndon	Raglesville, Ind.	12	1		
45	Union Coal Co.	Raglesville, Ind	Union	W. A. Jacobs	Raglesville, Ind.	15	1		
46	Washington Coal Co.	Washington, Ind.	Hawkins	Thomas Harris	Washington, Ind	22	3	2	
47	Washington Coal Co.	Washington, Ind.	No. 2						Suspended.

FOUNTAIN COUNTY.

48	Indiana Bituminous C. Co.	Terre Haute, Ind	No. 2	Steward Shirkie	Silverwood, Ind.	100	8	9	
49	Indiana Bituminous C. Co.	Terre Haute, Ind	Shipman						Abandoned.
50	M. Sturm	Silverwood, Ind	Sturm						

GIBSON COUNTY.

51	M. G. Berry	Oakland City, Ind.	Oakland			7	1	1	
52	Maule Coal Co.	Princeton, Ind.	Oswalt	Thomas Thomas	Princeton, Ind.	55	20	2	Sink'g escape shaft.

GREENE COUNTY.

53	Island Coal Co.	Indianapolis, Ind	Island No. 1	S. C. Risher	Linton, Ind	93	13	7	
54	Island Coal Co.	Indianapolis, Ind	Island No. 2	J. S. Newport	Linton, Ind	199	19	17	
55	Island Valley Coal Co.	Linton, Ind	Island Valley	Jos. Fennell	Linton, Ind	64	5	5	
56	Linton Coal Co	Linton, Ind	Fluhart	James Dunn	Linton, Ind	120	10	9	
57	South Linton Coal Co.	Linton, Ind	South Linton	Joe Ferry	Linton, Ind	50	4	3	
58	Summit Coal Co.	Bloomfield, Ind	Summit	Frank Lockhart	Linton, Ind	53	7	5	
59	Summit Coal Co.	Bloomfield, Ind	Templeton	Jno. Templeton	Linton, Ind	35	4	2	

Table Showing the Number of Mines, Men Employed, Etc.—Continued.

KNOX COUNTY.

Number.	OWNER.	ADDRESS.	MINE.	MINE BOSS.	ADDRESS.	EMPLOYES. Inside.	EMPLOYES. Outside.	Mules.	REMARKS.
60	Bicknell Coal Co . .	Bicknell, Ind . .	Bicknell	R. M. Freeman . . .	Bicknell, Ind	39	4	2	
61	H. Edwardsport Coal Co.	Edwardsport, Ind.	Edward	Chas. Harting . . .	Edwardsport, Ind.	50	7	3	
62	Prospect Hill Coal Co. . .	Vincennes, Ind . .	Prospect Hill . . .	Wm. R. Scott . . .	Vincennes, Ind . .	50	5	2	

MARTIN COUNTY.

Number.	OWNER.	ADDRESS.	MINE.	MINE BOSS.	ADDRESS.	EMPLOYES. Inside.	EMPLOYES. Outside.	Mules.	REMARKS.
63	The Bedford C. M. Co . .	Bedford, Ind . . .	Bedford	Matthew Dickie . .	Shorts, Ind	17	2	1	New mine.

OWEN COUNTY.

Number.	OWNER.	ADDRESS.	MINE.	MINE BOSS.	ADDRESS.	EMPLOYES. Inside.	EMPLOYES. Outside.	Mules.	REMARKS.
64	Lancaster Coal Co.	Clay City, Ind . . .	Lancaster, No. 4 .	Jas. F. Andrews . .	Clay City, Ind. . .	52	4	2	

PARKE COUNTY.

65	Brazil Block Coal Co	Brazil, Ind	Cox No. 3	George E. Davis	Coxville, Ind	18	18	2	Cleaning up after strike.
66	Brazil Block Coal Co	Brazil, Ind	Otter Creek	J. O. Lewis	Carbon, Ind.	74	6	4	
67	Calumet Coal Co	Chicago, Ill	Lyford No. 1.	J. F. Bailey	Lyford, Ind	14	8	2	Opening after strike.
68	Calumet Coal Co	Chicago, Ill	Lyford No. 2.		Lyford, Ind				Shut down.
69	Crawford Coal Co	Brazil, Ind.	Crawf. No. 1.	Wm. Spears	Brazil, Ind	148	7	8	
70	I. M. McIntosh & Co	Brazil, Ind.	McIntosh No. 1	Henry Schlatter	Brazil, Ind	142	8	5	
71	Otter Creek Coal Co	Brazil, Ind.	Mecca No. 1	James Skene	Mecca, Ind	43	4	6	
72	Otter Creek Coal Co	Brazil, Ind.	Mecca No. 2	Morgan Roberts	Mecca, Ind				On strike.
73	Parke County Coal Co	Rosedale, Ind	Parke No. 7						Abandoned.
74	Parke County Coal Co	Rosedale, Ind	Parke No. 8	Geo. Mitch	Rosedale, Ind	45	6	3	Open'g after strike.
75	Parke County Coal Co	Rosedale, Ind	Parke No. 6	I. H. Valentine	Rosedale, Ind	22	3	3	Open'g after strike.
76	Standard Coal Co	Brazil, Ind.	Standard	John Scott	Knightsville, Ind.	35	4	1	New mine.
77	Zeller, McClelland & Co	Brazil, Ind.	Columbia No. 1	George Myers	Knightsville, Ind.	150	9	12	Formerly "Superior."
78	Zeller, McClelland & Co	Brazil, Ind.	Columbia No. 2	John Chesterfield	Brazil, Ind	125	6	4	Formerly "Superior"

PERRY COUNTY.

79	Am. Cannel Coal Co	Cannelton, Ind	Cannelton	Geo. W. Briggs	Cannelton, Ind	40	7	5	
80	Bergenroth Bros	Troy, Ind	Troy	R. Walker	Troy, Ind	15	3	2	

PIKE COUNTY.

81	Cabel Kaufman Co	Washington, Ind	Hartwell	G. C. Potter	Augusta, Ind	48	6	6	
82	D. Ingle	Oakland City, Ind.	Ayrshire	John Jennings	Ayrshire, Ind	136	15	20	
83	The S. W. Little Coal Co	Evansville, Ind	Blackburn	Jno. Willey	Petersburgh, Ind	40	8	4	
84	The S. W. Little Coal Co	Evansville, Ind	Littles	A. Dodds	Littles, Ind	83	8	7	
85	W. H. Jackson	Oakland City, Ind.	Carbon Hill	B. Stinson	Ayrshire, Ind	25	3	2	

Table Showing the Number of Mines, Men Employed, Etc.—Continued.

SULLIVAN COUNTY.

Number.	OWNER.	ADDRESS.	MINE.	MINE BOSS.	ADDRESS.	EMPLOYES.		Mules.	REMARKS.
						Inside.	Outside.		
86	Dugger Co-op. C. Co	Dugger, Ind.	Briar Hill	R. W. Evans.	Dugger, Ind.	8	1	1	Shut down.
87	Hancock & Conkel	Farnsworth, Ind	Bunker Hill	Frank Smith	Farnsworth, Ind	53	6	6	
88	Harder Hafer C. Co	Del Carbo, Ind.	Star	Samuel Campbell	Del Carbo, Ind	104	16	5	Electric machines.
89	Indiana & Chicago C. Co	Dugger, Ind.	Dugger	H. A. Butler.	Dugger, Ind.	133	16	10	
90	Jackson Hill C. & C. Co.	Eagle, Ind.	Jumbo.	W. E. Evans.	Eagle, Ind.	128	21	18	Comp. air mach.
91	New Curryville C. Co	Shelburn, Ind.	Currysville	C. C. Hull	Shelburn, Ind	40	10	5	Comp. air mach.
92	New Pittsburgh C. & C. Co	Alum Cave, Ind.	Phenix, No. 1	W. F. Brown	Alum Cave, Ind.	104	20	15	Comp. air mach.
93	New Pittsburgh C. & C. Co	Alum Cave, Ind.	Phenix, No. 2	W. F. Brown	Alum Cave, Ind.	18	2	2	Comp. air mach.
94	Old Pittsburgh C. Co	Chicago, Ill	Harrison	Ed Stewart	Hymera, Ind	...	...	..	Reb'ld'g after fire.
95	Shelburn Mining Co	Shelburn, Ind	Shelburn	...	Shelburn, Ind	30	4	3	Comp. air mach.
96	Shelburn Mining Co	Shelburn, Ind.	Shelburn, No. 2	...	Shelburn, Ind	...	...	..	
97	Watson, Little & Co	Chicago, Ill	Bush Creek	...	...	...		.	Shut down.

VANDERBURGH COUNTY.

Number.	OWNER.	ADDRESS.	MINE.	MINE BOSS.	ADDRESS.	Inside.	Outside.	Mules.	REMARKS.
98	Diamond Coal Co	Evansville, Ind	Diamond	William Horst.	Evansville, Ind	36	7	4	
99	Evansville Union C. Co.	Evansville, Ind	Union	Pius Schultheis	Evansville, Ind	27	6	3	
100	John Ingle C. Co	Evansville, Ind	Ingleside	John Odell	Evansville, Ind	36	12	4	
101	H. A. Lozier.	Evansville, Ind	First Avenue	Frank Gendhar	Evansville, Ind	31	9	8	
102	Sunnyside C. & C. Co	Evansville, Ind	Sunnyside, No. 1	C. W. Baets	Evansville, Ind	45	10	12	Comp. air mach.
103	Sunnyside C. & C. Co	Evansville, Ind	Sunnyside, No. 2	...	Evansville, Ind	...	..	..	Shut down.

VERMILLION COUNTY.

104	Hamilton. Vannest & Co	Clinton, Ind.	Hazel Creek, No. 1.	Dexter Vannest	Clinton, Ind.				
105	Hazel Creek C. Co.	Clinton, Ind.	Fern Hill	Frank Dunlap.	Clinton, Ind.	97	12	17	
106	Indiana Bituminous C. Co	Terre Haute, Ind	I. B., No. 1	D. W. James	Clinton, Ind.	120	10	12	
107	Torrey Coal Co	Voorhees, Ind.	Torrey, No. 4	T. V. Robertson.	Voorhees, Ind	91	13	6	Comp. air mach.
108	McClellan, Eastman & Co	Clinton, Ind.	Buckeye	William Chesterfield	Clinton, Ind.	104	9	3	

VIGO COUNTY.

109	Coal Bluff Mining Co	Terre Haute, Ind	Diamond	Thomas Gregory	Fontanet, Ind.				Shut down.
110	Coal Bluff Mining Co	Terre Haute, Ind	Peerless	G. R. Anthony	Fontanet, Ind.				No rep. since strike.
111	Coal Bluff Mining Co	Terre Haute, Ind	Star						No rep. since strike.
112	Coal Bluff Mining Co	Terre Haute, Ind	Union	James Johnson	Fontanet, Ind.				No rep. since strike.
113	Coal Bluff Mining Co	Terre Haute, Ind	Victor	C. R. McGranahan	Fontanet, Ind.	13	1	1	Being finished.
114	Davis Bros	Elsie, Ind	Eagle	Ed. Davis	Elsie, Ind	10	2	1	
115	J. N. & G. W. Broadhurst.	Terre Haute, Ind	Broadhurst	J. N. Broadhurst	W. T're Haute, Ind.	20	3	2	
116	J. Ehrlich	Seeleyville, Ind	Seeleyville.						Shut down all year.
117	A. F. Miller	W. T're Haute, Ind.	Gruenholz		W. T're Haute, Ind.	10	2		
118	Ehrmann Coal Co	Terre Haute, Ind	Nickel-Plate	C. C. Hawkins	Terre Haute, Ind	52	6	5	
119	Loughner Coal Co	Seeleyville, Ind	Loughner			14	3	1	
120	Grant Coal Co.	Burnet, Ind	Grant	James Devonale.	Burnet, Ind	100	10	9	
121	Parke County Coal Co	Rosedale, Ind	Parke No. 10.						Shut down.
122	Risher & Murray	Clinton, Ind.	New Mine	J. W. Risher	Clinton, Ind.				No report yet.
123	T. H. Brick and P. Co.	Terre Haute, Ind		Robert Bieler	W. T're Haute, Ind.	9	1	1	Use their own coal.
124	Vigo Coal Co	Chicago, Ill	Vigo						Shut down.
125	Vigo County Coal Co	Seeleyville, Ind	Ray	Geo. West	Seeleyville, Ind	120	11	5	

WARRICK COUNTY.

126	John Archbold	Evansville, Ind	Star	Geo. Archbold.	Newburgh, Ind	30	5	4	
127	Pat Bartley	Evansville, Ind	Chandler	Pat Bartley	Evansville, Ind	13	3	2	
128	Kelley and Nester	Booneville, Ind	Gough	Wm. Nester	Booneville, Ind	8	2	1	
129			Howard						
130	W. H. Menden	Evansville, Ind	De Forest	D. B. Hall	Chandler, Ind.	16	3	1	
131	Lander-Wooley Coal Co	Evansville, Ind	Big Vein.	Wm. Wooley	Booneville, Ind	29	6	4	
132	Caledonia Coal Co	Booneville, Ind		Robert Lander	Booneville, Ind	15	2	1	

I give below a brief notice of the mines visited during the year by myself and assistant.

CLAY COUNTY.

No. 1 Mine.

Located in the northwest part of the the city of Brazil. This mine has been worked steadily during the year. Electric machinery is used here to mine the coal, and seems to be a pronounced success. The only objection I found here was to the quality of oil used. Some improvement has been made in this direction during the year in this and other mines.

Gart. No. 3 Mine.

Located on a branch of the T. H. & I. Railroad, two miles northwest of Harmony. This mine was not in operation during the greater part of the year. On two occasions when visited, the water was so high that I could not get down the shaft. No inspection was made during the year.

Gart. No. 5 Mine.

In the town of Cardonia. This mine was in good condition on both of my visits. The force of men employed here has been greatly reduced on account of the available coal being worked out. I found the employes here using the best oil to be obtained, with the result that, though the circulation of air was weak in some places, there was no smoke to be seen and men were doing their work in comfort. The mine boss, Andrew Gilmour, is to be highly commended for his successful efforts in bringing about this result.

Brazil Block No. 8 Mine.

Located on the Coal Bluff Branch of the C. & I. C. Railroad, near the north line of Clay County. The lower vein at this mine is being worked with electric mining machines and is the largest producer of block coal in the State. Very little work has been done in the top vein this year. This has mostly been removing pillars preparatory to abandoning parts of the mine. During the year the electric plant installation has been perfected, a new air shaft has been sunk, and a 20-foot fan erected. On my last visit I found that though the amount of air circulating was greatly in excess of the minimum required by law, many of the working places were unfit to work in on account of powder smoke and the impure oil used by the employes. I learn that this has been remedied to some extent since then, but where it is necessary to blast coal at all hours during the day, it is impossible to keep the air clear. This is the principal drawback to the successful use of machines, but it has not prevented this mine from working full time during the year.

BRAZIL BLOCK NO. 10 MINE.

Located one mile west of No. 8, has been closed during the greater part of the year. It was in good condition in the early part of the year. When last visited it had been but lately opened after being idle several months, and was in only fair condition. The object now is to remove the pillars and abandon that part of the mine which has been developed, and it will probably be finished early in 1897.

BRAZIL BLOCK NO. 11 MINE.

Lies southwest of No. 8. This is a new mine and has not been visited during the year. The mine boss, Robert J. Wallace, reports the air shaft completed and the mine in good condition.

All of the above mines are owned by the Brazil Block Coal Company, and are under the superintendence of J. H. McClelland, and P. J. Mooney, mining engineer for the company.

GLADSTONE MINE.

Located on the Coal Bluff branch of the C. & I. C. Railroad, on the line between Clay and Vigo Counties. It was in fair condition when examined early in the year. In the latter part of July the mine was flooded, and did not work again until November 19. On the last inspection it was found in bad condition, but a force of men are at work on repairs. This mine was developed without reference to surface conditions and quite an excavation has been made under a large creek that flows near the shaft. This is and will be a source of constant danger, but with the present force of pumps at the mine the water can probably be controlled.

BRIAR HILL MINE.

One mile northwest of Clay City. This mine has been in bad condition ever since I came into office. Lately, the greater part of the former works of the mine has been abandoned, and developments are being made in a new direction. The new part of the mine was in fair condition on my last visit, and later reports indicate an improvement.

HARRISON NO. 2 MINE.

Located three miles southeast of Clay City. In good condition when visited, as far as could be learned. Was not working on either of my visits.

BRAZIL BRICK AND PIPE CO. MINE.

One mile northwest of Brazil. Employs 12 men mining coal and clay for use in the works of the company. The mine was in fair condition when visited.

PRATT MINE.

One mile west of Perth on the Big Four Railroad. In good condition on my first visit. Found very bad oil being used when visited last, but fair current of air in all working places. Escape shaft has been repaired during the year and is now in good shape.

CRAWFORD NO. 2.

Located one mile northeast of Center Point. This is the best mine in the block coal field. It has every natural advantage for drainage and haulage. The coal is of regular height and has a good roof. The mine is well planned and the ventilation is good. On my first visit I found that the oil being used by the miners was sending a cloud of smoke out of the shaft as if a fire was burning below. I called the attention of the officials of the company to the fact and they took steps to improve it. I had no reason to complain of the oil here on my next visit. The other mines of the company were also benefited by the action taken on this account. I have been informed that only the best of oil is being sold at the stores patronized by the miners of the company.

CRAWFORD NO. 3 MINE

Located two miles northeast of Ashersville, is a new mine. I found it in excellent condition on the only visit I made to it. It was opened during the latter part of the summer.

WORLD'S FAIR MINE.

Located one mile northeast of Brazil, was found in good condition on each visit. Much of the work now being done is in drawing pillars preparatory to abandoning the mine. Very little work was done here during the summer, the company holding their coal for better prices.

DIAMOND NO. 3 MINE.

Located on northwest quarter section 7, township 13, range 7. This mine was in good condition in all respects on my last visit, though considerable trouble with faults in the coal has been met and a large part of the territory has been found not workable. This has necessitated a change in hauling and ventilating arrangements which kept the mine in bad condition for a time, but they are now completed.

EUREKA MINES.

East of Carbon, on the Big Four railroad. No. 1, after being worked with a small force for the greater part of the year was abandoned in the latter part of October, on account of the shaft buildings having been destroyed by fire. It will not be rebuilt, as the coal it would work can be reached from No. 2.

No. 2 was found in good condition on my last visit except in one quarter, which was being pushed to a connection with No. 1 mine. This has been completed since, and the ventilation is reported good. Some fears are felt of danger from water which has accumulated in the abandoned works of the old Chicago Mine. However, the best survey that can be made shows the two mines to be separated by a distance of 400 feet of solid strata, and also by a fault in the coal which was not passed through in the Chicago Mine, and no danger exists from any recorded part of the Chicago Mine. That is one of the few mines of which a map was filed on its abandonment, as the law requires.

FORTNER MINE.

One mile southwest of Turner, is a bituminous mine. There are so many openings that a complete system of ventilation of the mine is impossible. The coal lies very near the surface and natural ventilation gives all the air necessary.

EXCELSIOR MINE.

Located northwest of Perth, on the Coal Bluff Branch of the C. & I. C. railroad. This mine was idle during the greater part of the summer on account of water breaking in from the creek which runs near the shaft. It has recently been reopened and is being put in shape to work. It has not been inspected since it was flooded.

SUPERIOR MINE.

One-fourth of a mile west of Turner, on the T. H. & I. railroad. This mine is aired by a furnace and a fan, and has been found in excellent condition in all respects whenever it has been inspected. The vein is bituminous, of a good quality and has a good roof. It is owned and operated by P. Ehrlich, one of the oldest operators in the county.

MONARCH MINE.

Northwest of the city of Brazil, on the C. & I. C. railroad. It is operated in connection with the Monarch Sewer Pipe Works, and its product is all used by the company. About 10 men are employed mining coal and clay. The mine is in good condition, except that it has no second outlet. This will be constructed during the coming summer. There are probably not 5,000 square yards of excavation in the mine, but this could only be determined by a survey.

BRAZIL MINE.

Situated one mile north of the World's Fair. Three veins are worked at this mine. The middle vein has a bad roof, but no accidents have occurred from this cause during the year. The mine was in good condition when last inspected.

NICKEL-PLATE MINE.

Located one mile from the main line of the T. H. & I. Railroad on the Knightsville north branch. Two veins are being worked. This mine has been in operation several years, and most of the work now being done is in removing pillars preparatory to abandoning the mine. It was found in excellent condition on each of my visits during the year.

BURGER MINE.

At the north limits of Clay City. When visited was employing but four men under ground. I found all requirements of the law being complied with at that time. Ten men are reported as being employed under ground at the close of the year, but no inspection has been made since the force was increased to this number.

McINTOSH No. 2.

One mile southeast of Brazil. This mine is nearly worked out and will probably be abandoned early in the year 1897. The coal has been greatly disturbed by horsebacks, but was kept in good condition during the time work was being carried on. The owners and superintendent, Mr. Joseph Tribble, are to be commended for the work done here.

FAIRVIEW MINE.

Located on the C. & I. C. Railroad, four miles northwest of Brazil. Two veins are worked, and I found the mine being operated in compliance with the provisions of the mining law on both of my visits during the year. The upper vein is very wet and has a bad roof, requiring constant care to keep it safe and ventilated, but no complaint reached me at any time of its condition.

NELLIE MINE.

One mile southeast of Brazil. A small force of men have been worked here during the year. The west side of the mine has been worked out and the east side will probably be finished during the present season. The mine was in fair condition on both of my visits.

SAN PEDRO MINE.

Located north of Staunton. This mine was inspected but once during the year, as it was idle after April 30. It was found in good condition when inspected.

LOUISE MINE.

One and one-half miles northwest of Center Point, was visited several times but inspected only once, as it was idle on the other occasions. The single entry plan on which this mine has been developed renders it very difficult to ventilate, as constant watch is necessary over a large number of doors. Making allowance for this drawback, the mine was in as good condition as could be expected. The new work that is being opened is on the double-entry plan, and when rooms are finished in the old part of the mine ventilation can be more easily provided.

BRIAR HILL MINE.

South of Asherville, on the Center Point branch of the T. H. & I. Railroad, was idle during the first quarter of the year. Shortly after it was reopened I visited the mine and found it in fair condition and a force of men at work repairing air-courses and timbering entries. Later my attention was called to the fact that men were being carried out of the mine overcome by foul gases. On September 16 I made a visit to the mine and found several entries so bad that I did not go half way to the faces. I made some suggestions to Mr. Hoffmann as to remedies to be applied, and was gratified two weeks later to find that they had been carried out with good effect. Since then I have heard no complaints from that mine of the condition underground. I was later called to test the scales at this mine and found them badly out of order. This was the only case during the year where scales were not adjusted on my calling attention to their being out of order on my regular visit to the mine.

COLUMBIA NO. 4.

One-half mile southwest of the above, is a new mine. A very bad roof is found over the coal in most parts of the mine. On my first visits the air-courses had not been arranged at the bottom of the shaft and places were very smoky. On a second visit I found that a good current of air was circulating and that an escape shaft had been sunk. An endeavor is being made to push entries through that part of the territory where bad roof is found, and it is to be hoped that the attempt will be successful, as the mine is well equipped to handle a large output of coal.

ABANDONED MINES.

In addition to the above the following mines have been worked out and abandoned in Clay County during the year: No. 6 mine of the Brazil Block Coal Co.; Gartside mine of Watson, Little & Co.; American Beauty and Columbia mines of Zeller, McClelland & Co. Each of those was visited one or more times during the year previous to abandonment.

DAVIESS COUNTY.

CABEL NO. 4. MINE.

Owned by Cabel & Kauffman Coal Company. Operated by shaft. Located two miles south of Washington. This mine was inspected May 4 and found in good condition.

CABEL NO. 9.

Owned by Cabel & Kauffman Coal Company. Located two miles southwest of Washington. When last inspected the mine was found in good condition, with the exception of some few minor repairs, which the company agreed to attend to at once.

BEDFORD COAL COMPANY MINE.

Located on the E. & R. Railroad, two miles east of Blankenship. This mine has been opened within the past year. The coal is three feet thick and of excellent quality. At my inspection, made November 25th, I found the ventilation in bad shape and ordered the necessary changes made to place the mine in compliance with the law.

WINKLEPLECK MINE.

Owned and operated by the Odon Coal Company. Located one mile northeast of Raglesville. Operated by shaft fifty feet deep. The coal is three feet thick and of good quality. At last inspection several changes were ordered to place the mine in compliance with the law.

STOY MINE.

Located one mile east of Raglesville, two miles from E. & R. Railroad. Owned by Abraham Stoy & Son. At last inspection the mine was found in good condition.

WILSON'S MINE.

Located near Washington, Ind. This mine is nearly worked out, and at the time of my last visit they were working but few men, and the most of those employed were drawing pillars preparatory to abandoning it.

MONTGOMERY MINE NO. 1.

Located at Montgomery, Ind., on the B. & O. S. W. R. R. The coal at this mine is underlaid with fire clay of a very soft nature, which heaves and fills the air courses and roadways so that the ventilation is hard to keep in good shape. At last inspection the mine was in good condition.

MONTGOMERY MINE NO. 2.

This mine has been idle since last April, and I did not examine it on my visit in June.

MUTUAL MINE.

Located at Clark Station, on the B. & O. S. W. R. R. The coal at this mine is composed of a vein of cannel coal three feet thick and bituminous one and one-half feet thick, running together. This is one of the best regulated mines in the State.

FOUNTAIN COUNTY.

No. 2 Mine of the Indiana Bituminous Coal Company is the only one in this county employing sufficient men to come within the provisions of the mining law of the State. It is located about one and one-half miles northwest of Silverwood, on a branch switch from the Clover Leaf railroad. The mine ran well during the whole year, the coal being of good quality. It lies very irregularly both as to thickness and level, which makes it inconvenient to work, being difficult to drain, and making heavy hauling for mules. Some heavy cuts have been made to level hauling roads in the mine and some of the under clay was sold for manufacturing purposes. I was informed that it was in demand for making buff building brick, and gave good results. This stratum of clay is about eight feet thick. There is a good roof overlying the coal and the mine is very well ventilated. An escape shaft has been provided during the year, and was in good condition at the time of my last inspection.

The Shipman mine has not been operated during the year and the Sturm mine has been worked out and abandoned.

GIBSON COUNTY.

Has but one mine employing more than ten men—the Oswalt mine, at the crossing of the E. & T. H. and Air Line railroads, one mile north of Princeton. I noted in my last annual report the completion of the shaft at this mine and hoped for a speedy development of the vein. In this I was disappointed, as it was not until about the 1st of August that they began making reports to me. On August 25th I was notified that a fatal explosion had occurred in the mine, and on investigation I found that the main entries were driven only about 250 feet on each side of the shaft, and cross entries were just being turned. An air shaft was under construction. I called attention to some provisions of the statute which were not being complied with and found on my next visit that they had been followed, with the exception that instead of a speaking tube from the top to the bottom of the shaft a telephone was being used. On a later visit by Mr. Epperson it was found that some of the working places were generating fire damp and the proper attention was not being given to keeping parallel entries equally advanced, thereby allowing the air to return before reaching the working faces. This was remedied when I visited the mine two weeks later. I learned on this occasion that it was the practice of miners to burn the gas out of their places, and called the attention of the superintendent to the danger of the practice. He seemed to think, however, that there was no danger in firing a small amount of the gas. I found a sufficient amount of air circulating to carry out and dilute all explosive gases that could be given off by the coal or other strata, though there was only a small fan at the bottom of the shaft. A larger fan was being placed on the surface at that time and the superintendent reported to me after it was put in operation that a largely increased volume of air was in circulation. While talking of the time when the air shaft would likely be completed I made a calculation of the area excavated at that time and found it to be about 2,000 square yards. The air shaft was then being pushed as rapidly as possible and I thought would be down to the coal before 5,000 square yards had been excavated. In these circumstances I had no power to curtail the working force of the mine nor to enforce any safety rules I might recommend. In another part of this report I give a copy of evidence taken by the coroner in investigating an explosion here.

GREENE COUNTY.

ISLAND VALLEY MINE.

Located two miles southeast of Linton, on the I. & V. R. R. The coal is five feet thick and of excellent quality for steam and domestic purposes. Operated by a shaft fifty-two feet deep. The output at this place is about 300 tons daily. When last inspected several changes were ordered to put the ventilation in good condition. Sixty men are employed at this mine.

ISLAND NO. 1 MINE.

Owned by Island Coal Company. Located one and one half miles south of Linton. Operated by a shaft sixty-six feet deep. This is a machine mine. They are working eleven Harrison machines, and they also have the latest improved machinery for hauling and screening the coal. The coal is five feet thick and of good quality. At last inspection the mine was in good condition.

ISLAND NO. 2 MINE.

Located at Linton. Owned by Island Coal Company. Operated by a shaft ninety-five feet deep. This is a machine mine, one of the largest in the State. They work twenty-two Harrison machines. The capacity of this place is 1,200 tons daily. The coal is five feet thick and of excellent quality. They have a rope haulage at this place. At last inspection the mine was in good condition.

SUMMIT MINE.

Located one mile west of Linton on the I. & V. Branch R. R. Operated by a shaft ninety-five feet deep. This mine at present is working with one-half force, having lately started, as it is one of the mines affected by the bituminous strike. I have visited this mine three times during the past year and found the mine in good condition.

SOUTH LINTON MINE.

Located one mile south of Linton, on the I. & V. Branch R. R. The coal is five feet thick and of good quality. Operated by a shaft eighty-one feet deep. This mine is among the best ventilated in the State. I have made two inspections of it during the year and found no recommendations necessary.

TEMPLETON'S MINE.

Located three-fourths of a mile southwest of Linton. This mine heretofore has been working on a small scale, employing less than ten men; but during the past year they have put in machinery and built a switch and are now in a fair way of developing a large mine.

FLUHART MINE.

Located one and one-half miles southwest of Linton. This mine has been inspected three times during the past year and found in good condition, with the exception of the first visit when several changes were ordered to improve the ventilation.

KNOX COUNTY.

BICKNELL MINE.

Located at Bicknell. I have visited this mine twice during the past year, and at both inspections I found the mine in excellent condition.

EDWARDSPORT MINE.

Has been entirely remodeled during the year. Under the supervision of V. G. Brent a shaft was sunk and machinery erected to hoist the coal, the slope formerly used as a hoist way now being used only as an escape way. The capacity of the mine is thereby largely increased, and it is being developed rapidly; and I confidently expect that it will soon be one of the large mines of the State. It has the advantage of high coal, good top and bottom, and fair grades for haulage.

PROSPECT HILL MINE.

Located at Vincennes, Ind. This mine has been inspected twice during the year, and found in fair condition. They have been working less than ten men during a part of the year, but at present they are working something over that force, and are making preparations for putting down a manway or second outlet. The operators of Knox County have continued working their mines during the whole year, having paid the price demanded by the miners.

PARKE COUNTY.

COX NO. 3 MINE.

Near Coxville on the C. & I. C. railroad. Only one visit was made to this mine during the year on account of its being idle from April 30th to the early part of December. The same is true of all bituminous mines in this county, they being affected by the strike noticed in another part of this report. At present the mine is being overhauled, and air courses are being changed, as many falls of roof occurred during the time the mine was idle, closing those that had been used. This is one of the bes equipped mines in the State, two fans being used for ventilation. The coal is mined by machines driven by compressed air, and a screening and washing plant makes it possible to prepare coal for market to the best possible advantage.

OTTER CREEK MINE.

This is a block coal mine situated on a branch of the Big Four Railroad, about two miles northeast of Carbon. It is being worked out, preparatory to abandonment.

LYFORD NO. 1 MINE.

During the first four months of 1895 this mine was operated regularly, and some very necessary improvements were made in the direction of better ventilation. A rope haulage system was also put in operation, and the mine was in fair condition on my last visit. Since the beginning of the strike on May 1st it has not been inspected. But the probabilities are that it is in bad condition, as it has a very bad roof. This is the worst feature of the mine, as it is dry and the coal is of good quality.

LYFORD NO. 2 MINE.

This mine was in fair condition early in the year, but has not been in operation since May 1st.

CRAWFORD NO. 1 MINE.

Two miles northeast of Carbon, is a block coal mine. Two veins are worked. Was inspected twice during the year and found in good condition on both occasions. It was operated very irregularly during the year, part of the time on account of poor car service on the part of the Big Four Railroad, but principally on account of dull trade.

McINTOSH NO. 1 MINE.

On the Coal Bluff Branch of the C. & I. C. Railroad, three-fourths of a mile north of No. 8 mine, in Clay County. The upper vein at this mine has been abandoned, and all work is now being done in the lower vein. The shaft buildings were burned during the fall, but have been rebuilt in good condition. The underground plan of the mine is good, and it ranks well for safety and ventilation, and coal can be handled with comparative ease.

PARKE NO. 6 MINE.

One mile northwest of Rosedale. This mine was found in fair condition on the only visit made to it during the year. No work was done in the mine from May 1st to December 1st, and consequently the mine was not visited during that time.

PARKE NO. 8 MINE.

One-half mile west of No. 6. The remarks made in regard to that mine apply to this, except that a small force of men were at work during November.

MECCA, NOS. 1 AND 2

Near Mecca on a branch of the C. & I. C. Railroad. Have good roof and coal of fair height, and of good quality. No. 1 lost considerable time during the year on account of differences between the operators and miners. Was found in good condition when last inspected, all the requirements of the law being complied with. No. 2 has been operated regularly with a small force of men, and is nearly worked out.

STANDARD MINE.

One-fourth mile west of McIntosh No. 2. Is reached by a switch from the C. & S. E. Railway. This is a new shaft and is sunk through two veins of block coal. On my last visit work was begun in the bottom vein to develop the mine. Both veins here are of good thickness and will be worked at the same time. Ventilation is provided for by a 12-foot diameter fan with an air way on one end of the shaft, a separate air shaft not being sunk yet. H. V. Sherburne is superintendent.

COLUMBIA NO. 1 MINE.

Formerly known as Superior No. 1. Lies one-fourth mile north of the above. This mine is being operated in the upper vein of block coal, has a bad roof, lies very uneven and makes a great deal of water. This makes it very difficult to keep air courses open, and I have never found the mine up to the standard in this respect, though a great improvement has been made lately, and it was in fair condition on my last visit.

COLUMBIA NO. 2 MINE.

One-half mile southwest of the above. During the present year the shaft has been sunk to the bottom vein of block coal and opened out in that. No work has been done in the upper vein since January of this year. It is reached by a switch from the C. & S. E. Railroad, and also from the Coal Bluff Branch of the C. & I. C. Road, the tower being arranged to load coal on opposite sides of the shaft for each road. Last year all coal was shipped over the Chicago & Southeastern Railroad, and it was not found satisfactory. Connection was made with the C. & I. C. during fall of 1896. The mine is in good condition.

OTHER MINES.

Parke No. 7 was abandoned in April, 1896, after having been inspected once this year.

Watson, Little & Co. began sinking a shaft about one mile northwest of Columbia No. 1 during the summer, but encountered a stratum of running sand which proved to be too heavy for the timbers they were using in the shaft, and work was suspended. The company fell into financial difficulties, and have not resumed operations. Drillings show a vein of good coal underlying a large territory in that vicinity, which will probably be developed in the near future.

PERRY COUNTY.

CANNELTON MINE.

Located three miles northeast of the City of Cannelton. The coal is hauled to the river at Cannelton by a small locomotive in hopper cars. The coal lies in the hills above water level, which gives good drainage. Ventilated by a furnace with good results. In excellent condition on both of my visits.

TROY MINE.

One-half mile from Troy, near the Ohio River. The coal is loaded directly into boats, and is consumed mostly by the river trade. The mine is ventilated by a furnace, which, when properly attended to, furnishes a sufficient amount of ventilation. The roof is of a massive sandstone, thirty feet thick, so that there is practically no danger from that source. No accidents of any kind have been reported from this mine during the last two years.

PIKE COUNTY.

HARTWELL MINE.

This mine is located near Augusta, on a branch of the Air Line Railroad. It was inspected twice during the year and found in good condition on both occasions. Reports have been very irregular and unsatisfactory since the appointment of G. C. Potter to succeed Thomas Small as superintendent.

AYRSHIRE MINE.

This mine is located near the Air Line Railroad, six miles east of Oakland City, and is the largest mine in the county. A coke plant of large capacity is located here, but has done very little work during the year. Has been visited twice during the year. On my last inspection I found that several brattices and stoppings had been removed for the purpose of making a survey of the old works, and had not been replaced. The mine boss, Mr. Jennings, reports these repaired and shows the mine in good condition, which, I think, is correct.

BLACKBURN MINE.

Located on the E. & I. at Blackburn Station. Was inspected but once during the year and found in excellent shape. It was closed down several months during the summer, and on my last visit was not in operation.

LITTLE'S MINE.

At Little's Station on the E. & I. Railroad. This mine has the most natural advantages of any in the State, in the way of good roof, easy grades for haulage, and good facilities for drainage. Under the efficient superintendence of Andrew Dodds advantage has been taken of all those conditions, with the result that it is a model mine. From my observation I think that the relations between the operator and workmen are entirely harmonious, and the town is a quiet and peaceable community, peopled entirely by the employes of the mine and their dependents.

PIKE COUNTY.

CARBON HILL MINE.

One mile west of Ayrshire on the Air Line Railroad. Has been developed during the year, and was visited but once. Found no recommendations necessary, as the safety of the workmen seemed to be assured as far as foresight could provide, and ventilation was good. The probabilities are that the capacity of this mine will be largely increased in the near future, as the proprietor, Mr. Wm. H. Jackson, of Oakland City, is an energetic business man with the push and means to make his undertaking a success.

SPENCER COUNTY.

The mines of this county have not been operated during the year to an extent that would bring them under the provisions of the mining law of the State. This is a disappointment, as I had expected the output to be increased from several of the mines of this county during the year.

SULLIVAN COUNTY.

CO-OPERATIVE MINE.

One-half mile southwest of Dugger, on the I. & I. S. R. R. Has been run on a very small scale during the year. A second outlet by a slope has been provided and the requirements of the law are being met in all respects. The mine was in fair condition when last inspected. It is now being worked under lease by a company of miners on the co-operative plan, about eight men being interested and doing all the work.

DUGGER MINE.

Has railroad facilities from both the I. & V. and I. & I. S. railroads. The operators paid the 60-cent rate for mining and operated the mine all year. I found it in fairly good condition on each of my inspections, and such recommendations as I found necessary to make were promptly and cheerfully complied with.

BUSH CREEK MINE.

Has not been in operation since May 1st, as it has been affected by the failure of the owners, Watson, Little & Co., of Chicago, and there is no immediate prospect of its resuming operations.

Bunker Hill.

At Farnsworth, on the I. & I. S. Railroad. The mine was idle on account of the strike, which affected nearly all the mines in this county. When inspected after resuming work it was found in excellent condition. Its roof and bottom are of such a character that it is easily kept in good working condition, and under the care of Mr. Frank Smith it is well looked after.

tar Mine.

Located at Gramercy Park, on a branch of the T. H. & I. R. R. Was idle for nearly three months on account of the strike mentioned in another part of this report. Since beginning operations its capacity has been greatly increased, and it is now producing about thirty car loads of coal daily. It is equipped with electric machines and they seem to be doing satisfactory work. Mr. A. D. Scott is in charge as superintendent.

Jumbo Mine.

Located at Jackson Hill. Since last report considerable improvements have been made here, and it is now in fair condition. On my last visit it was not thoroughly repaired after the idleness caused by the strike.

Currysville Mine.

One mile north of Shelburn, on the E. & T. H. R. R. Use mining machines driven by compressed air. This mine is in very bad condition in spite of all efforts on my part to bring it up to the standard of mines in the State. While conditions are very unsatisfactory, they are not so bad as to justify closing the mine. There is some improvement since my last year's report, but there is room for a great deal more.

Phenix Mines, Nos. 1 and 2.

At Alum Cave, on a branch of the E. & T. H. This mine has been worked out near the shaft and there is some difficulty in carrying air into the working places. The coal from both mines is hoisted through the shaft at No. 1. The output is about thirty railroad cars per day. On my last visit the mine had been gone over carefully under instructions from this office and was in fair condition.

HARRISON MINE.

At Hymera, on the Farmersburg branch of the E. & T. H. The shaft here was burned as a result of trouble growing out of the strike of bituminous miners. Four miners were arrested for complicity in the burning. Two were released on preliminary examination, and the others were found not guilty by a jury in Sullivan Circuit Court. The trouble arose over an agreement made by miners and operators on the price to be paid for mining coal by machinery, the mine being equipped with electric machinery. A difference of opinion as to what was a fair price for machine mining, when the pick mining rate was 60 cents, existed here as at other machine mines in the bituminous district and may cause trouble in the future.

SHELBURN MINE, NOS. 1 AND 2.

At Shelburn on the E. & T. H. railroad. These mines were in good condition at the time of each of the three inspections made during the year. This mine is one of the few in the State that generates fire-damp in dangerous quantities, but under the careful supervision of Mr. Thomas Thomas no accidents have been reported during the year from this cause.

VANDERBURGH COUNTY.

DIAMOND MINE.

Was inspected twice and found in fair condition on the first visit. Considerable improvement had been made, and on my second I considered no recommendations necessary.

UNION MINE.

This mine is operated by a company of miners, all of whom are at work about the mine in some capacity. The escape shaft spoken of in my last report has been completed and the mine is in good condition.

INGLESIDE MINE.

This mine was found in excellent condition on both of my visits and no recommendations were considered necessary.

FIRST AVENUE MINE.

This mine has changed ownership during the year, and the new proprietor has spent considerable money in improvements and seems to be determined to put the mine in first-class condition. This had not been accomplished at my last visit, but progress was being made in that direction.

SUNNYSIDE MINE.

Under the efficient and energetic management of Mr. Wm. Moody great improvements have been made in this mine and the underground work is being placed in splendid condition. Compressed air machines are used, and the coal is gotten out in good shape. Roads are dry and the ventilation leaves very little to be desired.

VERMILLION COUNTY.

FERN HILL MINE.

One mile southwest of Clinton, reached by a switch from the C. & E. I. Railroad. Is in splendid condition. On my first inspection I found a good current of air circulating, but so loaded with smoke from the lamps or the workmen as to be unfit to work in. I found that this had been remedied to a great extent on a subsequent visit, and later reports are that only good oil is being used in the mine. The second outlet to this mine is by a slope and is used altogether by men and mules entering and leaving the mine, none being hoisted on the cages at the main shaft.

INDIANA BITUMINOUS COAL COMPANY'S NO. 1 MINE.

Three-fourths mile south of the above, on the same railroad switch. Is one of the best equipped mines in the State for the rapid handling of coal, and is well developed underground. I found the mine in excellent condition when inspected, except that two pairs of entries had recently been started, and the proper doors and bridges had not been put in place to direct the air into them. When this is done there can be nothing further asked to make this a model mine.

BUCKEYE MINE.

One mile east of Fern Hill mine. This mine is being operated in the lower vein of coal with good success. During the year an air-shaft has been sunk and properly equipped. The roof over the coal is good, and all indications point to the development here of a large mine. Some fire-damp is given out by the coal, and two accidents have occurred from this cause, which are noted in their proper places. The mine is now in good condition for safety and ventilation.

TORREY NO. 4 MINE.

At Geneva. Has been greatly improved during the year and is now in good condition, except that some water is lying on the road to the escape shaft. A pump is kept at the escape shaft to dry this road, and it is usually kept in a condition to be available in case of accident. No further attempt has been made to develop the lower vein since my last report. This mine has been kept in operation during the entire year and is now producing about 500 tons per day from the upper vein, and this is being constantly increased.

HAZEL CREEK NO. 1 MINE.

Was abandoned early in the year.

VIGO COUNTY.

DIAMOND MINE NO. 2.

Two miles southwest of Fontanet. Was found in fair condition when inspected, but the fan was not throwing the amount of air it should. The mine boss agreed to remodel it and put a stairway in the escape shaft, but the strike of May 1 caused a suspension of work at the mine and it has not resumed operations since, and no inspection has been made to learn whether my suggestions have been followed. There is no immediate prospect of this mine being put in operation.

PEERLESS MINE.

One-half mile north of the crossing of the Big Four Railroad on the C. & I. C. Railroad. Has been operated very little and was not inspected during the year.

STAR MINE.

Is now being operated by a company of miners under a lease to take out the coal remaining in the mine. Pillars only.

UNION MINE.

Northeast of Fontanet. Has been driven into better roof than was found near the bottom of the shaft, and all places seemed to be safe and well ventilated on my last visit, and no improvements were recommended. The mine has recently begun operations, after having been idle since May 1.

VICTOR MINE.

On account of the strike this mine is not yet abandoned, but will be within three months according to my best information. It is all pillar work and dangerous, but has been worked very carefully, and no accidents have been reported from there since my last report.

BROADHURST MINE.

One mile southwest of Macksville. Has been operated on a small scale for several years, the product being hauled in wagons to the city of Terre Haute. It is now employing over twenty men and will probably increase the number. I found the mine in fair condition below, but no safety catches, signal bell at bottom, nor speaking tube. These have been provided and the mine is now in good shape.

EAGLE MINE.

On the Brazil Branch of the C. & E. I. Railroad, two miles south of Fontanet. Has been at work all year except when prevented by water. It is opened by a slope on the south side of Otter Creek and has been flooded twice this year. On my last visit the water was out but the mine was in bad condition, the air-courses having been closed by falls of roof while the mine had been idle. Efforts were being made to open new airways, with some prospects of success. I have not learned later what has been done. I visited the mine four times during the year in an endeavor to have the law complied with and had succeeded fairly well before the first flood.

GRUENHOLZ MINE.

One mile northwest of Macksville. Has been operated for several years with four or five men. The present proprietor has started to develop it, so that he can employ about thirty men. It was inspected but once during the year, and several improvements were recommended. When these are made the mine will be safe to work, and will probably be quite largely developed, as there is a good deal of coal in that vicinity.

NICKEL PLATE MINE.

One mile southwest of Eagle mine. The coal lies here nearly on a level with the valley up which the railroad switch runs. The mine is developed under the hills on each side, and is ventilated by two fans. A haulage plant has been placed on the west side of the mine during the year. The roof is bad on the east side, and very little work is being done there. Openings made to daylight in several places allow air to escape, and weakens the current, but it was in fair condition on my last visit.

RISHER'S MINE.

Located on property adjoining the Gruenholz mine on the east and north. There was a shaft sunk during the fall of 1896, and but little work has been done in the coal. I have no report from it yet, and on my last visit to that vicinity the shaft had not reached coal, so I did not inspect it. Coal will probably be shipped in considerable quantities from this mine in 1897. A switch from the Vandalia railroad is to be constructed to furnish shipping facilities.

PIPE WORKS MINE.

At the plant of the Terre Haute Brick and Pipe Works. Employs from eight to twelve men to furnish fuel for the works. It is worked on the double entry plan, and is aired by a steam jet. Was in fair shape when inspected.

GRANT MINE.

One-half mile south of the town of Grant, on the Brazil branch of the C. & E. I. railroad. The escape shaft has been repaired and made available for use during the year, air courses have also been cleaned out and brattices tightened, and the ventilation greatly improved. On the last inspection the mine was found in fair condition. Air has to be carried so far through old works that there will always be trouble with the ventilation. Compressed air machines are used for mining the coal here.

VIGO MINE.

Adjoining the Eagle mine on the east. Was badly ventilated on my first visit. It was improved by the construction of an outlet for air near the working face, and cleaning out air courses. The mine has not resumed operations since the inauguration of the bituminous miners' strike, May 1st.

RAY MINE.

East of Seeleyville on the T. H. & I. railroad. Has been operated during the whole year unaffected by the miners' strike. The price asked for by the organization was paid, and no trouble was had in securing miners. The air shaft at this mine has been completed, and the mine has since been kept at all times in first-class condition.

Loughner Mine.

A new mine on the T. H. & I. railroad one-fourth mile west of Seeleyville. This mine has not been inspected since coal was reached. Some coal has been shipped and this will probably be a large mine as the company has 200 acres of coal adjoining their shaft.

Parke No. 10 mine and J. Ehrlich's Seeleyville mine have not been in operation at any time during the year.

ACCIDENTS.

In the following pages I give tables including all accidents reported to this office during the year, giving the date of the accident, name of the person injured, extent of the injury sustained, the cause of the accident, the mine and county in which the accident occurred. There has been some trouble in getting satisfactory reports from mine bosses, and I am of the opinion that some report injuries which others consider too trivial to mention. In order to make those tables of the greatest possible value all accidents should be reported with such a description of the injuries received as would enable the inspector to determine approximately, at least, the amount of time lost from work by injuries received while at work, and where an accident can be classified as serious the law should provide for immediate notification to the Inspector as is now done in case of fatal accidents, so that an immediate inspection of the mine and examination of the person injured may be made. In several cases where death has resulted from injuries received in accidents, the injured party has lingered from three days to a week before death, and in the meantime such changes had been made in the condition of the mine that an inspection of the place where the accident occurred threw no light on its cause.

The serious and fatal accidents are fully reported to the best of my knowledge, with one or two exceptions. No comment is made except in case of fatal accidents where personal investigation gave a knowledge of the facts more fully than was obtained from the reports made by persons in charge of the mines where they occurred.

Minor Accidents.

DATE.		NAME.	INJURY.	CAUSE OF INJURY.	MINE.	COUNTY.
Jan.	3.	James Lindsay	Head hurt	Kicked by a mule	Phenix No. 1	Sullivan.
“	4.	John Cook	Finger mangled	Climbing ladder	Gart No. 3	Clay.
“	6.	Arthur Hilliar	Arm hurt	Nail in old tracking	Gart No. 5	Clay.
“	8.	Reuben Yocum	Slightly bruised		Briar Hill	Clay.
“	8.	Theodore Thompson		Kicked by a mule	Dugger	Sullivan.
“	9.	John Bennett	Head and hand hurt	Fall of coal	Gart No. 5	Clay.
“	11.	Ott Powers	Face cut	Struck with shovel	Gart No. 8	Clay.
“	20.	Robert Davis	Slightly hurt	Falling slate	Nellie	Clay.
“	22.	Robert Foster	Leg slightly injured	Between mine cars	Diamond No. 3	Clay.
“	23.	Jacob Tucker	Shoulder bruised	Falling slate	Star	Sullivan.
“	25.	Thos. Jacobson	Shoulder dislocated	Falling slate	Gart No. 8	Clay.
“	27.	Pat Lauler	Arm hurt	Mine cars	Fluhart	Greene.
Feb.	13.	Pat Hart	Leg hurt	Fell on loose slate	Lyford No. 1	Parke.
“	17.	John Tipton	Bruised	Falling coal	San Pedro	Clay.
“	17.	Pete Bulger	Finger tips mashed	Mine car	Phenix No. 1	Sullivan.
“	18.	William Allen	Hand slightly hurt	Falling slate	Nellie	Clay.
“	20.	Mike Valuski	Back hurt	Falling slate	Lyford No. 1	Parke.
“	28.	Nelson Richard	Leg hurt and head cut	Fall of draw slate	Crawford No. 2	Clay.
“	28.	John Trowbridge		Mine car and mule	Cabel No. 9	Daviess.
Mar.	10.	A. Butterman	Leg hurt	Fall of coal	Superior	Clay.
“	12.	Wes Hillion	Hand hurt	Shovel caught in machine	Gart No. 8	Clay.
“	16.	Frank Mullen	Finger hurt	Spragging mine car	Star	Vigo.
“	18.	J. Gillian	Head cut	Draw slate fell	Excelsior	Clay.
“	20.	J. E. Quill	Arm hurt	Coupling mine cars	Dugger	Sullivan.
“	25.	Lewis Anstett	Burned	Powder	Ingleside	Vanderburgh.
“	28.	James Flockhart	Foot hurt	Between mine cars	Crawford No. 2	Clay.
Apr.	8.	Fred Burg	Slightly hurt	Falling slate	Briar Hill	Clay.
“	14.	Harvey Gatt	Right hand hurt	Mine cars	Dugger	Sullivan.
“	16.	M. Graham	Arm hurt	Between cars	Fern Hill	Vermillion.
“	21.	Mat Unity		Falling slate	Union	Vigo.
“	24.	M. F. Collins	Ankle strained	Falling coal	Island No. 1	Greene.
“	25.	Robert Boskill	Toe bruised	Mine cars	Gart No. 8	Clay.
“	27.	Jasper Lucas	Shoulder and back hurt	Falling coal	Crawford No. 2	Clay.
“	27.	James Charles, Sr		Mine car off track	Eureka No. 2	Clay.
“	27.	F. Beckerly	Scalp wound, 4 inches	Falling coal	Sunnyside No. 1	Vanderburgh.
“	28.	Andrew Petterson	Slightly hurt on foot	Falling draw slate	Star	Vigo.
“	29.	John Strouskia	Finger hurt	With slack shovel	Gart No. 8	Clay.
May	21.	Ed. Shattuck	Finger mashed		Diamond	Clay.
“	23.	Anthony Frank	Legs bruised	Falling draw slate	Cabel No. 9	Daviess.
June	2.	Christian Thorn	Squeezed slightly	Mine car	Cannelton	Perry.
“	12.	James Walker	Finger mashed	Mine car	South Linton	Greene.

Minor Accidents—Continued.

DATE.	NAME.	INJURY.	CAUSE OF INJURY.	MINE.	COUNTY.
June 12.	Henry Bettle	Slightly injured	Fell down shaft	Phenix	Sullivan.
“ 16.	Emil Ostia	Hip bruised	Fall of draw slate	Cabel No. 9	Daviess.
“ 19.	Tom Barr	Hip bruised	Fall of coal	Phenix	Sullivan.
“ 23.	Thomas Wilson	Burned	Defective oil	Ingleside	Vanderburgh.
“ 23.	Robert Dalzal	Foot mashed	Falling coal	Union	Vanderburgh.
July 3.	Albert Johnson	Foot bruised	Mine cars	Cannelton	Perry.
“ 12.	Barney McVickers	Slightly hurt	Draw slate	Gart No. 5	Clay.
“ 17.	D. Skelly	Ankle hurt	Mine cars	Pratt	Clay.
“ 17.	Sam Genet		Draw slate	Brazil Block No. 1	Clay.
“ 17.	Wm. McCarrin	Foot hurt	Mining machine	Brazil Block No. 8	Clay.
“ 22.	E. J. Graves	Hand bruised	Draw slate	Briar Hill	Clay.
“ 28.	Joe Wilson	Shoulder bruised	Draw slate	Brazil Block No. 8	Clay.
“ 28.	C. Riggs	Face and arm bruised	Mine cars	Pratt	Clay.
“ 28.	James Rose	Slightly hurt	Falling coal	Island Valley	Greene.
“ 28.	George Burge	Back injured	Falling draw slate	Dugger	Sullivan.
“ 28.	Wm. Goodman	Arm hurt	Mine cars	Dugger	Sullivan.
“ 28.	James Lawson	Body bruised	Falling coal	Dugger	Sullivan.
“ 28.	John Cullers	Fingers hurt	In shaft	Dugger	Sullivan.
“ 28.	Fred Spalding		Draw slate	Dugger	Sullivan.
Aug. 6.	William Phelps	Back hurt	Falling roof	Silverwood	Fountain.
“ 6.	Berry St. John	Ankle hurt	Draw slate	Dugger	Sullivan.
“ 12.	Dick Atchison	Leg hurt	Slate on pillar	American Beauty	Clay.
Aug. 18.	John Miller	Foot bruised	Falling slate	Brazil Block No. 1	Clay.
“ 18.	Ed. Griffith		Slate fell on entry	Dugger	Sullivan.
“ 18.	Sam Marlow		Slate fell on entry	Dugger	Sullivan.
Sept. 16.	Wm. Stevenson	Foot injured	Mine car	Crawford No. 2	Clay.
“ 16.	J. Neidlinger	Head cut	Falling slate	Briar Hill	Clay.
“ 19.	Ed. Buck	Knee hurt		Eureka No. 1	Clay.
“ 25.	Henry Mullen	Foot hurt	Mine car	World's Fair	Clay.
Oct. 8.	Enos Pedot	Arm hurt	Fall of coal	Fairview	Clay.
“ 12.	Tom Jones, Jr.	Foot hurt	Mine car	Crawford No. 1	Parke.
“ 21.	Wm. Dudley	Fingers bruised	Mining machine	Brazil Block No. 8	Clay.
“ 27.	Sim Yemm	Foot bruised	Falling coal	Crawford No. 2	Clay.
“ —.	Allen Hourst	Bruised	Shot through pillar	Edwardsport	Knox.
Nov. 6.	John Ochrin	Leg hurt	Falling slate	Brazil Block No. 8	Clay.
“ 12.	Mike Moss	Finger cut	Mining mabhine	Brazil Block No. 8	Clay.
“ 14.	James McAnulty	Slightly injured	Draw slate fell	Brazil Block No. 1	Clay.
“ —.				Columbia No. 1	Parke.
Dec. 3.	John Johnson	Shoulder hurt	Falling slate	McIntosh No. 2	Clay.
“ 7.	Emmet Bosden	Thumb mashed	Mine cars	Island No. 2	Greene.
“ 15.	Geo. Williams	Bruised	Draw slate	Brazil Block No. 1	Clay.

"	15.	Fred Neece	Burned	Premature blast	Grant	Vigo.
"	17.	Wm. Lewis	Hip hurt	Falling slate	Fluhart	Greene.
"	18.	Joe Drake	Hand sprained		Phenix No. 1	Sullivan.
"	24.	Andrew Maxwell	Finger mashed	Falling coal	South Linton	Greene.
"	24.	Nick Wools	Bruised	Falling coal	South Linton	Greene.
"	—.	G. D. Stevens	Foot bruised	Dumping coal	Brazil Block No. 8	Clay.
"	29.	E. Rice	Leg hurt	Fall of coal	Island Valley	Greene.
"	—.	Joe Ranes	Slightly hurt	Fall of coal	Bunker Hill	Sullivan.
"	—.	Paul Perrard	Head hurt	Falling slate	Brazil	Clay.
"	—.	James Dalton		Falling cage	World's Fair	Clay.
"	—.	James Dalton		Kicked by mule	Eureka No. 2	Clay.
"	—.	Wm. Osborn	Eye injured	Fire from pick	Eureka No. 2	Clay.

Serious Accidents

DATE.		NAME.	INJURY.	CAUSE OF INJURY.	MINE.	COUNTY.
Jan.	8.	Wm. Handy	Struck on head	Shot through pillar	Bush Creek	Sullivan.
"	12.	Joseph Chad	Leg broken	Falling slate	Silverwood	Fountain.
"	15.	Frank Slack	Collar bone broken	Fall of coal	Gart No. 5	Clay.
"	16.	Isaac Womeldorf	Ankle mashed	Railroad cars	Fluhart	Greene.
"	17.	Jesse Davis	Leg broken		Lyford No. 1	Parke.
"	27.	Andrew Alsman	Shot in side	Through pillar	Bush Creek	Sullivan.
Feb.	3.	Henry Ruk	Foot mashed	Falling slate	Union	Vigo.
"	3.	Mike Miller	Hand mashed	Coal fell down shaft	Lyford No. 1	Parke.
"	8.	Wm. St. Clair	Leg broken in two places	Falling slate	B. B. No. 1	Clay.
"	10.	John Pittston	Leg broken	Fall of coal	Pratt	Clay.
"	10.	Mort Sheppard	Both arms broken	Caught in elevator	Jumbo	Sullivan.
"	14.	David Hermanson	Finger cut off		Diamond No. 3	Clay.
"	18.	Jos. Frankoner	Collar bone broken	Falling slate	Pratt	Clay.
"	21.	Charles Deal	Leg broken	Falling slate	Brazil Block No. 1	Clay.
Mar.	12.	Claude Peck	Leg broken	Falling slate	Superior No. 1	Parke.
"	24.	John Dunbar	Finger broken	Loading mine car	Dugger	Sullivan.
"	5.	George Dunbar	Wrist dislocated	Between mine car and roof	Cabel No. 9	Daviess.
Apr.	8.	P. W. Jones	Hand mashed	Falling slate	Briar Block	Clay.
"	10.	John Lipp and two others	Slightly burned	Explosion of fire-damp	Buckeye	Vermillion.
"	24.	James Lyden	Hurt in back	Fall of rock	Shelburn	Sullivan.
"	28.	Wm. Epperson	Needle through foot		Island Valley	Greene.
May	7.	Chas. Harson	Collar bone broken	Mine cars	Fern Hill	Vermillion.
"	—.	Enos Bright	Shoulder dislocated	Fuel car	Lyford No. 2	Parke.
June	20.	A. Bouvie	Seriously hurt	Falling slate	Superior No. 1	Parke.
"	—.	Sam Harvey	Leg broken	Mine cars	Torrey No. 4	Vermillion.
July	25.	Thomas Liddle	Leg mashed	Mine cars	Diamond No. 3	Clay.
Aug.	8.	S. A. Gantz	Badly bruised	Bar slipped and struck him	Brazil Block No. 1	Clay.
"	13.	Tom Jones	Leg broken	Falling slate	Gladstone	Clay.
"	13.	Elmer Davis	Badly bruised	Mine cars	Nellie	Clay.
"	18.	Fred Miller	Head cut	Falling slate	Brazil Block No. 1	Clay.
"	20.	Harvey Gatt	Arm broken	Mine cars	Dugger	Sullivan
"	20.	W. Evans	Leg broken	Draw slate fell	Dugger	Sullivan
"	—.	Chas. Bradford	Leg broken	Falling slate	Nickel Plate	Vigo.
"	—.	—— Driver	Ankle mashed		Torrey No. 4	Vermillion.
"	25.	Frank Turber	Badly burned	Explosion of fire damp	Oswalt	Gibson.
Sept.	14.	Thos. Barrowman	Leg broken	Falling slate	Diamond No. 3	Clay.
"	15.	John McQuade	Badly bruised	Went back to a shot before it exploded	Diamond No. 3	Clay.
"	15.	James Smith	Three ribs broken			
"	17.	Frank Vance	Arm broken	Falling slate	Brazil Block No. 8	Clay.
"	19.	George Steubel		Falling slate	Brazil Block No. 1	Clay.
"	28.	Henry Creon	Foot broken	Falling slate	World's Fair	Clay.

"	—.	Wm. Vail	Hand mashed	Falling coal	Nickel Plate	Clay.
"	—.			Falling coal	Columbia No. 1	Parke.
Oct.	6.	John Bedwell	Ankle broken	Falling slate	Island No. 2	Greene.
"	7.	John Bennie	Ribs broken	Mine car	Island Valley	Greene.
"	9.	Dan Jones	Leg broken	Falling slate	Louise	Clay.
"	25.	David Suttie	Hand badly bruised	Falling coal	Gart No. 5	Clay.
"	30.	John Nickelson	Arm mashed	Mine cars	Briar Hill	Clay.
"	—.	Lafe Singleton	Burned	Blast	First Avenue	Vanderburgh.
Nov.	4.	F. Hamilton	Badly hurt	Crossing under cage	Fern Hill	Vermillion.
"	18.	Marion Hasket	Badly bruised	Shot through pillar	Nickel Plate	Vigo.
"	—.	Jabez Wilde	Leg broken	Cross-bar fell	Brazil Block No. 11	Clay.
"	—.				Columbia No. 1	Parke.
Dec.	2.	Tom Moses	Hand mashed	Mine car	Fluhart	Greene.
"	8.	Henry Pirtle	Hand mashed	Railroad car	Fluhart	Greene.
"	16.	J. Prudo	Leg broken	Timber fell on him	Lyford No. 1	Parke.
"	17.	Harvey Bilderback	Leg broken	Falling coal	Blackburn	Pike.
"	26.	Frank Turber	Leg broken and burned	Explosion of gas	Oswalt	Gibson.
"	29.	Chas Byers	Leg broken	Falling slate	Brazil Block No. 11	Clay.
"	29.	Lawrence Byers	Cut in back			
"	26.	Arthur Colgate	Leg broken in two places	Explosion of fire damp	Oswalt	Gibson.
"	26.	Wm. H. Grills	Severely burned			
"	26.	Dave Nolan	Severely burned			
"	26.	T. W. Trice, colored	Slightly burned			
"	26.	James Turner	Slightly burned			

Fatal Accidents.

DATE.	NAME.	Age.	NATIVITY.	Widow.	Orphans	CAUSE OF INJURY.	MINE.	COUNTY.
Jan. 11	Gabriel Datta		Austrian			Caught by cage in shaft.	Brazil Block No. 10	Clay.
Jan. 29	Chas. Doyle	64	Scotland	1	2	Falling slate	Superior	Clay.
Mar. 8	Matthew Hofman	71	Germany	1		Falling slate	Eagle	Vigo.
Mar. 17	Perry O. McCarty					Mine cars ran away	Old Pittsburgh	Sullivan.
Apr. 6	Andrew Ferguson	16	Indiana			Cage in shaft	Gart No. 5	Clay.
July 15	Frank Chevalier	40	France	1	4	Falling slate	Superior No. 1	Parke.
Aug. 25	Chas. Gostnell	28	Illinois	1		Explosion fire damp	Oswalt	Gibson.
Aug. 30	Robt. Barnes		Indiana			Explosion in sinking sha't	Buckeye	Vermillion.
Sept 3	Peter Rance					Fell down sha't	Prospect Hill	Knox.
Sept. 3	Wm. D. Downs	21	United States			Fell down shaft	Broadhurst	Vigo.
Sept. 26	Wm. Bradshaw	26	England			Falling slate in room	Diamond No. 3	Clay.
Oct. 5	Raymond Cooper	22	Indiana			Squeezed by mine car	Montgomery	Daviess.
Oct. 17	Jno. Schlatter	43	Pennsylvania	1	5	Drilling out dynamite	Standard	Parke.
Oct. 20	Jno. Pfiester	30	Indiana			Fall of slate	Nellie	Parke.
Nov. 7	——— Matzura	35	Austria	1	2	Fall of slate	Brazil Block No. 8	Clay.
Nov. 7	Chas. McClintock	30	Indiana	1	3	Shot through pillar	Nickel Plate	Vigo.
Nov. 14	Anton Krauss	32	Germany		2	Found dead under cage	Brazil Block No. 8	Clay.
Dec. 2	John Lynch	51	Scotland	1	3	Slate fell on entry	Columbia No. 1	Parke.
Dec. 4	Marion Noble	43	United States	1	8	Slate fell in room	Columbia No. 3	Clay.
Dec. 12	Oliver Vanness	28	Indiana			Slate fell on entry	Pratt	Clay.
Dec. 18	Henry Miller	45	United States	1		Caught by mine car	Nickel Plate	Clay.
Dec. 26	James Riall			1		Explosion of fire damp	Oswalt	Gibson.
Dec. 26	Jno. Ernst			1	2	Explosion of fire damp	Oswalt	Gibson.
Dec. 26	Jno. Holmes			1	2	Explosion of fire damp	Oswalt	Gibson.
Dec. 26	C. Poneleit					Explosion of fire damp	Oswalt	Gibson.
Dec. 26	R. Poneleit			1	4	Explosion of fire damp	Oswalt	Gibson.
Dec. 26	R. A. Maule			1		Explosion of fire damp	Oswalt	Gibson.
Dec. 26	Theodore Faber			1	1	Explosion of fire damp	Oswalt	Gibson.

In the following table is shown the number of accidents which occurred in each county during the year, whether minor, serious or fatal, divided as to their causes as given:

COUNTY.	Fall of Roof.	Fall of Coal.	Hurt by Mine Cars.	Explosion of Fire Damp.	Premature Blasts.	Caught by Cages.	Railroad Cars.	Kicked by Mules.	Fell Down Shaft.	Miscellaneous.	Totals. Minor. Serious. Fatal.
Clay	18	6	8	0	0	1	0	1	0	13	47
	13	4	3	0	2	0	0	0	0	3	25
	6	0	1	0	0	3	0	0	0	0	10
Daviess	2	0	1	0	0	0	0	0	0	0	3
	0	0	0	0	0	0	0	0	0	0	0
	0	0	1	0	0	0	0	0	0	0	1
Fountain	1	0	0	0	0	0	0	0	0	0	1
	1	0	0	0	0	0	0	0	0	0	1
	0	0	0	0	0	0	0	0	0	0	0
Gibson	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	9	0	0	0	0	0	0	9
	0	0	0	8	0	0	0	0	0	0	8
Greene	2	4	3	0	0	0	0	0	0	0	9
	1	0	2	0	0	0	2	0	0	1	6
	0	0	0	0	0	0	0	0	0	0	0
Knox	0	0	0	0	1	0	0	0	0	0	1
	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	1	0	1
Owen	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0
Parke	1	0	1	0	0	0	0	0	0	2	4
	2	1	1	0	0	0	0	0	0	4	8
	2	0	0	0	1	0	0	0	0	0	3
Perry	0	0	2	0	0	0	0	0	0	0	2
	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0
Pike	0	0	0	0	0	0	0	0	0	0	0
	0	1	0	0	0	0	0	0	0	0	1
	0	0	0	0	0	0	0	0	0	0	0
Sullivan	6	3	4	0	2	0	0	2	1	1	19
	2	0	1	0	2	0	0	0	0	2	7
	0	0	1	0	0	0	0	0	0	0	1
Vanderburgh	0	2	0	0	0	0	0	0	0	1	3
	0	0	0	0	1	0	0	0	0	0	1
	0	0	0	0	0	0	0	0	0	0	0
Vermillion	0	0	1	0	0	0	0	0	0	0	1
	0	0	2	1	0	1	0	0	0	1	5
	0	0	0	1	0	0	0	0	0	0	1
Vigo	2	0	1	0	1	0	0	0	0	0	4
	2	0	0	0	1	0	0	0	0	0	3
	1	0	0	0	1	0	0	0	1	0	3
Warrick	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0
Minor.	32	15	21	0	4	1	0	3	1	17	94
Serious	21	6	9	10	6	1	2	0	0	11	66
Fatal	9	0	3	9	2	3	0	0	2	0	28
Totals	62	21	33	19	12	5	2	3	3	28	188

As minor and serious accidents are not reported until the end of the month in which they occur no investigation of such accidents is made, and my information in regard to them is confined to the facts contained in the report as given by the mine boss. I have investigated every fatal accident that has occurred in the State during the past year, with one exception – the case of John Pfiester at the Nellie mine I was absent from home when that occurred, and when I returned the coroner had completed his investigation. An attempt to notify me had been made by Mr. Evans, and no blame can be attached to him under the statute providing a penalty for failure to notify the Inspector.

Of the deaths caused by falls of roof during the year nearly all were in the working places of the men injured and where they were charged with the duty of keeping the places safe. This is true in all but the case of John Lynch, who was killed by a fall of slate on an entry which was used as a hauling road and traveling way. Men who were fully competent to discharge the duties of their position as timber men testify that two days before the accident the stone which caught him appeared to be perfectly safe. While there might be a possibility of the operator of the mine being held liable in a damage suit in this case, it seems to me that all reasonable precautions had been taken to prevent the accident which occurred. All the accidents which occurred by mine cars might have been averted by the persons injured complying with the law which requires that no person shall ride on loaded cars.

With one exception the deaths occasioned by the explosion of gas occurred in the new mine of the Maule Coal Co., at Princeton. The explosions there being fully discussed in another part of this report need not be noticed further here. The death in Vermillion County was caused by an accumulation of explosive gas in an air shaft which was being sunk. It stands alone as far as my observation or reading goes. While the gas might have been expelled by continuing to run the fan a few minutes longer, there was no reason, so far as I know, to apprehend that such an accumulation should occur in that place.

One death and several serious accidents occurred by shots blowing through pillars. With a view to making persons in charge of mines more careful in this respect I have introduced a bill requiring maps of mines to be made and copies filed with the Inspector of Mines. This will cause mine bosses to be more careful in driving rooms and entries. Of those accidents that occurred in shafts, one was an unexplainable accident. A young boy who had recently begun work in the mine had got on the cage to come up at the end of his day's work when, by some means, he lost his balance and fell and was caught on the side of the shaft. The others were caused by a failure to observe the law in regard to signals and the number of men allowed to ride on a cage.

Of those who fell down shafts, one was a night man whose duty it was to hoist water from the shaft before the day turn came on. In arranging to do so he hoisted the cage too high, and intending to step on the cage he walked into the shaft. The other attempted to step on a cage ascending the shaft and missed it. Of all the twenty eight fatal accidents there could be a question of liability in but two.

The Inspector should be notified when any serious accident occurs, and I shall attempt to have an act to that effect passed by the Legislature. Some fatal accidents might have been prevented if the Inspector had been notified of non-fatal accidents which had occurred at the same places.

SMALL MINES.

I have tried during the year to collect statistics from small mines in the State and have sent blanks to all small operators whose addresses I have learned. I give below a list of those who have reported, with the men employed and coal produced. These are all who have responded out of over 200 who were requested to do so.

CLAY COUNTY.

		Men.	*Tons.*
Markland Coal Company	Clay City	9	4,000

DAVIESS COUNTY.

Odon Coal Company	Odon	7	1,600
George A. Denson	Alfordsville	4	640
Union Coal Company	Raglesville	9	840
J. M. Myers	Epsom	8	900

FOUNTAIN COUNTY.

James Morgan	Kingman	6	920
B. F. Lindley	Coal Creek	2	186
Edward Perry	Cates	3	2,000
Levi Bird	Kingman	8	6,000
John W. Shuster	Stone Bluff	2	480
Silverwood Coal Company	Silverwood	..	2,600
J. S. Tiley	Coal Creek	6	500

GIBSON COUNTY.

M. T. Berry	Oakland City	8	3,000

KNOX COUNTY.

R. C. Vance	Edwardsport	2	750
George Weaver	Wheatland	5	1,200
Herrington Coal Company	Edwardsport	Just opened.	

MARTIN COUNTY.

		Men.	Tons.
Johnson & Chenoweth	Shoals	4	625
Philip Gammon	Shoals	3	320
Albert Payton	Short	4	200
Dr. S. H. Brittain	Loogootee	4	400
J. W. Strange	Loogootee	5	380
John T. McAuley	Loogootee	1	100
Hiram Davis	Loogootee	6	3,600
PARKE COUNTY.			
N. C. Walker	Rockville	8	2,000
WARRICK COUNTY.			
Albert Phillips	Boonville	1	280
Frank Haberstrok	Boonville	2	400
Andrew J. Bullock	Boonville	1	40
Henry Phillips	Yankeetown	1	350
N. W. Reynolds	Boonville	8	2,100
E. Whitmer	Boonville	1	320
Caledonia Coal Company	Boonville	12	12,735
DeForest Coal Company	Evansville	9	1,000
Wm. H. Stone	Boonville	6	2,000
Bartley, Day & Bro	Midway	8	3,000
Total		163	45,466

In addition to the above, several reported more men, and I have placed them in the list of large mines found in another part of this report. The thirty-four mines given in the above list report a total of 163 men and 45,466 tons of coal produced during the year. I think it is safe to add twice as much for those not reporting, which would bring the totals up to 489 men and 136,398 tons.

I have recommended the following amendments to the mining law of the State, and shall endeavor to have them passed through the Legislature:

1. Making provision for better communication between the workings and escape way.
2. Providing that the Inspector be immediately notified of all accidents in mines, as is now required in case of fatal accidents.
3. Providing for making maps of mines, and filing copies with the Inspector.
4. Providing for the examination of mine bosses, fire bosses and hoisting engineers at mines.
5. Providing for the use of a pure oil in mines.
6. Providing for inspection of mines employing less than ten men.

The passage of either of these laws will tend to greatly improve the conditions of mining in the State, and make the work of inspection more effective, and my experience convinces me that all are necessary.

ROBERT FISHER,
State Inspector of Mines.

REPORT OF THE STATE SUPERVISOR OF OILS.

Office of the State Supervisor of Oil Inspection,
Room 92, State House,
Indianapolis, Ind.

Prof. W. S. Blatchley,
State Geologist of Indiana:

In accordance with the statute providing for the appointment of a State Supervisor of Oil Inspection, and to regulate the use and sale of oils for illuminating purposes, I herewith submit my second annual report, the same being the report for the calendar year 1896.

Respectfully,

C. F. HALL,
State Supervisor of Oil Inspection.

REPORT OF THE STATE SUPERVISOR OF OILS.

During the year 1896 but one change was made in the force of deputies under my charge, Mr. W. C. Zaring having been appointed Deputy Inspector at Evansville, Ind., on November 1, 1896, to fill a vacancy at that point. The list of Deputy Supervisors in the State on December 31, 1896, was, therefore, as follows:

Zaring, Wm. C	Evansville.
Weems, Robert F	Vincennes.
Dorsey, C. B	New Albany.
Bowman, M. J	Madison.
Mills, L. B	New Maysville.
Shirk, B. F	Muncie.
Boltz, J. H	Winchester.
Dorsey, W. C	Terre Haute.
Carr, W. C	Crawfordsville.
McGee, Wm. H	Lafayette.
Davidson, James G	Whiting.
Johnston, John M	Logansport.
Daly, W. F	Peru.
Sebring, W. D	Portland.
Thorward, Theo	Fort Wayne.
Schutt, M. A.	Michigan City.
Derr, Walter	South Bend.
Cornell, J. B	Goshen.

During the twelve months which have elapsed since my last report I have inspected 52,327 barrels of oil, and my deputies and assistants 209,823 barrels; of this number but 122 barrels were rejected as against 551 barrels in 1895, thus showing that the oil companies have been shipping a higher grade of oil into this State.

The standard test for all illuminating oils in Indiana is gravity test, Beaume's hydrometer, not below 46° nor higher than 50°. Said oils must bear a flash test not below 120° Fahrenheit, and a fire test not below 140° Fahrenheit. This test being higher than several other States in the Union, is the reason our rejections are so few, the lower grades of oil being shipped to other States.

No violations of the law regarding oil inspection have come to my notice during the year 1896.

But one or two minor accidents, resulting from the explosion of kerosene, have occurred within the State, and they were due to lamps having been accidently upset, rather than to the quality of oil.

INSPECTION BY STATIONS.

STATIONS.	Approved.	Rejected.	Total.
Evansville	18,385		18,385
Vincennes	7,585		7,585
New Albany	3,461		3,461
Jeffersonville	2,964		2,964
Madison	3,477		3,477
Aurora	2,610		2,610
Brookville	1,960		1,960
Greensburg	1,532		1,532
Rushville	1,641		1,641
Connersville	1,801		1,801
Shelbyville	1,684		1,684
Columbus	2,102		2,102
Danville	1,354		1,354
Spencer	8		8
Union City	2,070		2,070
Muncie	2,618		2,618
Richmond	4,140		4,140
Indianapolis	52,205	122	52,327
Terre Haute	12,541		12,541
Brazil	2,876		2,876
Rockville	754		754
Crawfordsville	2,948		2,948
Lafayette	14,920		14,920
Frankfort	1,955		1,955
Kokomo	2,381		2,381
Logansport	8,338		8,338
Rochester	1,358		1,358
Delphi	1,380		1,380
Whiting	14,815		14,815
Hammond	4,113		4,113
Valparaiso	1,509		1,509
North Manchester	766		766
Peru	3,822		3,822
Bluffton	1,382		1,382
Marion	2,068		2,068
Huntington	2,484		2,484
Portland	1,260		1,260
Decatur	243		243
Fort Wayne	11,958		11,958
Angola	630		630
Auburn	270		270
Columbia City	270		270
Lagrange	270		270
Ligonier	180		180
Butler	270		270
Topeka	60		60
South Bend	8,964		8,964
Walkerton	177		177
Argos	120		120
Plymouth	485		485
Michigan City	1,892		1,892
Laporte	2,203		2,203
Crown Point	233		233
Elkhart	5,262		5,262
Warsaw	1,026		1,026
Goshen	2,471		2,471

INSPECTION BY STATIONS—Continued.

STATIONS.	Approved.	Rejected.	Total.
Bourbon	344	....	344
Knox	120	....	120
Nappanee	120	....	120
Louisville, Ky	7,118	....	7,118
Cincinnati, O	3,905	....	3,905
Toledo, O	1,853	....	1,853
Lima, O	11,249	....	11,249
Mansfield, O	532	....	532
Cleveland, O	6,102	....	6,102
Hamilton, O	288	....	288
Chicago, Ill	146	....	146
Total number barrels inspected for year	262,028	122	262,150

INSPECTION BY MONTHS.

MONTH.	Approved.	Rejected.	Total.
January	35,369	....	35,369
February	24,134	....	24,134
March	22,955	....	22,955
April	14,807	....	14,807
May	13,394	....	13,394
June	13,144	122	13,266
July	12,813	....	12,813
August	12,440	....	12,440
September	21,620	....	21,620
October	30,740	....	30,740
November	29,747	....	29,747
December	30,865	....	30,865
Total number barrels inspected by months	262,028	122	262,150

TABLE SHOWING PLACE OF MANUFACTURE.

Whiting, Ind	111,121
Lima, O	109,874
Cleveland, O	11,225
Oil City, Pa	9,178
Washington, Pa	5,903
Toledo, O	4,853
Pittsburg, Pa	3,441
Titusville, Pa	2,733
Welker, O	1,387
Findley, O	605
Reno, Pa	315
Franklin, Pa	243
Rosenburg, Pa	230
Altoona, Pa	215
Emlenton, Pa	187
Warren, Pa	146
St. Louis, Mo	145
Dunkirk, Pa	115
Newburg, O	115
Freedom, Pa	80
Dayton, O	20
Chicago, Ill	19
Total	262,150

TABLE SHOWING STATES WHERE OIL WAS MANUFACTURED.

Ohio	128,079
Indiana	111,121
Pennsylvania	22,786
Missouri	145
Illinois	19
Total	262,150

Very respectfully,

C. F. HALL.

GEOLOGY OF VIGO COUNTY, INDIANA.

BY DR. J. T. SCOVELL.

INTRODUCTORY.

Vigo County is situated on the western boundary of Indiana, about midway between Lake Michigan and the Ohio River. It has an extent of 24 miles from north to south, and is a little less than 17 miles in average width, having an area of about 406 square miles.

The county is bounded on the north by Vermillion and Parke counties, on the east by Clay County, on the south by Sullivan County and on the west by Clark and Edgar counties, Illinois.

According to the United States survey, the county is in townships 10, 11, 12 and 13 north of the base line of Indiana, which is 38° 30′ north latitude; and in ranges 7, 8, 9, 10 and 11 west of the second principal meridian, which is 86° 28′ west of Greenwich.*

The Wabash River flows southwesterly through the county, so that about one-fifth lies west and four-fifths east of the river. The county is divided into twelve civil townships. On the north there are Nevins and Otter Creek east of the river and Fayette on the west; then Sugar Creek on the west, with Harrison and Lost Creek east of the river; then Riley, Honey Creek and Prairieton, and on the south Prairie Creek, Linton and Pierson, all east of the river.

The immediate valley of the river in Vigo County is from four to five miles wide, occupying about one-fourth the area of the county. The river at the ordinary stage of water has an average width of about 600 feet. Low water at Terre Haute, near the middle of township 12 north, is about 445 feet above sea level. The river and its flood-plain occupy the western third of the valley, the eastern portion being a broad terrace. The flood-plain or first bottoms rise from 14 to 20 feet above low water in the river, while limited areas of "second bottoms" rise from 10 to 15 feet above the flood-plain. The terrace rises from 50 to 75 feet above low water in the river, but toward the south, in Prairie Creek Township, it merges into the flood plain.

The highlands on either side of the valley have an elevation of from 100 to 200 feet above the river, the bluffs in some cases being quite abrupt. The greater part of the county is drained by the Wabash and its tributaries. The principal streams from the west are Brouilett's Creek, Coal Creek, Sugar Creek (with several large branches), Clear Creek and Hawk Creek. These streams rise in Illinois and flow southeasterly into the river through valleys from one-quarter to one-half a mile wide and from 30 to 80 feet in depth. The streams from the east are Otter Creek, Lost Creek, Honey Creek, Prairie Creek, Turman's Creek and Busseron Creek. Portions of Pierson and Riley townships are drained by Splunge Creek into Eel River. The valleys of the river and its tributaries seem to be the channels of an earlier drainage system that have been partly filled with sand and gravel, so that in many cases the beds of the present streams are from 25 to 100 feet above the rocky beds of the older channels. These smaller streams for much of the summer are "lost creeks," a fairly good stream among the hills disappearing in the sands and gravels of the main valley.

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*Unfortunately the numbers of the ranges and townships were omitted on the map of Vigo County, accompanying this report. Pierson Township is 10 N.; Riley, 11 N.; Lost Creek, 12 N., and Nevins, 13 N. Two tiers of sections on the east side of Nevins Township are in range 7 W.; Pierson Township is in R. 8 W.; Linton in R. 9 W., and Prairie Creek in ranges 10 and 11 W.

The rocks of the county, as seen in the bluffs and in the beds of streams, and as revealed in ordinary wells and mines, are the sandstones, shales, limestones and coals of the Carboniferous Age.

The soils are in general of glacial origin. In the valleys there are alluvial sands and clays and wide areas of black prairie soil resting on a subsoil of sand and gravel. On the uplands the top soil is usually a fine white clay, resting on a subsoil of yellow clay, which passes gradually into the boulder clay or hard pan which lies upon the bed-rock. Along the eastern margin of the main valley there are extensive areas of dune sand, and at some localities in the eastern bluffs there are thick beds of loess.

That portion of the county drained by Splunge Creek, slopes gently toward Eel River and the soil seems to be sedimentary, appearing to have been deposited over the bed of an ancient lake.

The temperature is that of the middle temperate zone, possibly somewhat modified by the waters of the river. The rainfall is generally abundant and well distributed. The soils are varied and fertile, producing a luxuriant growth of vegetation. A large portion of the terrace in the main valley and the greater part of Splunge Creek valley were originally prairies covered with valuable forage grasses, but the flood plains and uplands were covered with forests of oak, black walnut, yellow poplar, birch, maple, elm, ash, sycamore, hickory and other valuable trees.

In Vigo County the conditions are specially favorable for successful coal mining, for the growing of grain and market garden products, for stock raising and for many forms of manufacturing.

The population and wealth of Vigo County, being the second in the State, the growth and development of Terre Haute, the fourth city in the State, give some indication of the material resources of this county.

ELEVATIONS.

The elevation of the following important localities are taken from railway levels, and are adjustable to the level of the rail at the Union Station at Terre Haute, near the center of section 22–12–9. This point, as given by Gannett, is 492 feet above tide; by some it is given as 485 feet:

Rail at the Union Station (Gannett)	492 feet.
Ellsworth, on the Logansport road	492 feet.
Atherton, on the north county line	523 feet.
Hill one-half mile east of Atherton	625 feet.
Rosedale, one mile north of county line	537 feet.
Grant, on Big Four railroad	516 feet.
Fontanet, Nevins Township	539 feet.
Coal Bluff, on Otter Creek	553 feet.
Lodi, on the county line	564 feet.
Perth, on the plateau in Clay County	633 feet.
Point one mile west of Seelyville	596 feet.
Seelyville Station	585 feet.
A point one mile east of Seelyville	604 feet.
East county line on the Vandalia	583 feet.
Spring Hill Junction, west of center of section 11–11–9	516 feet.
Honey Creek bridge, northeast northwest 17–11–8	505 feet.
Lockport Station	569 feet.
Highlands east of Lockport	622 feet.
County line, on the Southeastern railroad	614 feet.
Honey Creek bridge, on the Evansville road	509 feet.
Youngstown Station	578 feet.
Albin's hill, beyond Youngstown	604 feet.
Hartford or Pimento	600 feet.
County line on Evansville road	575 feet.
Farmersburg, one-half mile south of line	573 feet.
The west county line on the Vandalia	544 feet.
Point one mile west, on the plateau	581 feet.
Station at St. Mary's	555 feet.
Sandford, on the county line west	625 feet.
Morainic Hills, near Sandford	655 feet.
Yaw's Hill, northeast quarter section 18–10–8	673 feet.
Crapo's Hill, northwest quarter section 20–10–8	663 feet.
Surface of Lake Erie	573 feet.
Surface of Lake Michigan	582 feet.

GENERAL GEOLOGY.

Vigo County is a portion of the eastern slope of the great central valley of North America, and has been involved in many of the major geological events of the continent.

The earth for the most part is composed of oxygen, silicon, aluminum, iron, calcium, sodium, potassium, carbon, magnesium, hydrogen, sulphur, chlorine and nitrogen. Oxygen, the most abundant of these elements, unites with each of the others, forming a group of compounds called oxides.

Water is an oxide of hydrogen. Silica or quartz is an oxide of silicon. It is the hardest and most enduring of the rock forming minerals. It is the main ingredient of sand and sandstone rocks, and is abundant in granite rocks.

The oxide of silicon combined with the oxide of aluminum forms the silicate of aluminum or kaolin. The silicate of aluminum, combined either with the silicate of potassium, the silicate of sodium, or the silicate of calcium, or with either two of these substances, forms a group of rock forming minerals called feldspars. They enter into the composition of lavas, granites, shales, slates and clays. The oxide of carbon combined with the oxide of calcium forms calcium carbonate, or calcite. It is the basis of many of the limestones and marbles, so abundant in the crust of the earth. Magnesium limestones are a combination of calcium and magnesium carbonates called dolomite. The oxides of iron, called hematite, and magnetite are abundant minerals that constitute the greater part of the iron ores. Calcium sulphate or gypsum, calcium phosphate, sodium chloride or common salt, graphite and the various forms of coal are important minerals.

It is supposed that the materials which make up the earth were once a mass of intensely heated gases, and that in time the greater part became a molten liquid, and that finally the outer portions of the liquid mass became solid. As the mass cooled irregular contractions gave rise to broad, low swells, and wide, shallow depressions, the elevations gradually becoming continents and the depressions, becoming deeper, formed the ocean beds.

The first elevations of the continent doubtless included the area now known as Vigo County. The rocks of these primal elevations were probably a somewhat homogeneous mass of alkaline silicates, much like a bed of lava. There were no sandstones nor limestones, no shales nor granites, no iron ores nor coals, just a mass of materials from which these different kinds of rocks have been formed.

The ocean waters and the vapors of the atmosphere were intensely acid. As they and the slag-like crust reacted upon each other the air gradually became pure, the rocks were dissolved and broken down, the waters lost their acids and became charged with sodium chloride, calcium carbonate, and other compounds; silicates of aluminum, potassium, sodium, calcium and other materials of feldspars were formed and spread out over the ocean bed as sediments of clay, and alongside of, or mingled with these clay sediments were beds of sand composed of quartz and other materials of the disintegrated rocks. As the conditions became favorable the lower forms of vegetation, as algæ and seaweeds, appeared in the shallow coast waters, becoming very abundant. The remains of this vegetation in many cases gave rise to carbonaceous sediments, possibly something like peat beds. Through the agency of this vegetation iron sediments in great quantities were formed.

Later, as animal life became abundant, lime sediments began to accumulate from the skeletons and shells of these lower forms of life. As these sediments thickened the lower portions under the influence of heat, moisture and pressure became rocks; sandstones, shales, shaly sandstones, coal, iron ore and limestones being examples. Thus for millions of years these sediments and rocks were forming on all sides of the central area which was continually rising, while the ocean beds with their load of sediments were continually settling. These processes do not seem to have been absolutely continuous, as there are evidences that in some cases, wide areas were raised above the sea, and for ages subjected to the action of eroding agents. Then they were again submerged and covered with sediments.

Finally a great change began, the central regions were depressed and the adjacent sediment receiving areas were raised above the sea. A broad area extending from the region of Lake Superior northeastward to Labrador and northwestward to the Arctic Ocean, was changed from the bed of the sea to the nucleus of a continent. At the same time extensive areas were elevated along the region of the Appalachian Mountains, including the Ozark region, and elevations were formed along the region of the Rocky Mountains.

These land masses formed the nucleus from which the continent has grown. They have furnished much of the material from which the rocks of the central areas have been formed.

Under the influence of the heat and pressure attending these changes of the earth's crust these early rocks became crystalline. The sandstones were changed to quartzites, the clays and shales to slates; the shaly sandstones and sandy shales to granites, gneisses, etc.; the coals to graphite; the iron sediments to iron ores; the limestones to crystalline limestones and marbles. These changes closed a period in the geological history of the earth which is called the *Archæan* or beginning age. The earlier rocks of this era are sometimes called Laurentian rocks, from their occurrence along the St. Lawrence River, while the later strata are known as Huronian or Algonkian rocks.

The Cambrian Era.—This era began with the formation of extensive sandstone strata along the borders of the Archæan lands. The Potsdam sandstones of New York and the pictured rocks of Lake Superior belong to this era. Whether these strata extended over the region of Indiana may not be positively known, but Professor Cubberley in the 18th Report of the Geology of Indiana, represents the deep wells at Indianapolis, Richmond, Bloomington, Frankfort, South Bend and Connersville, as reaching the Potsdam sandstone.

Heavy beds of Magnesian limestone in Tennessee and Missouri belong to this era, but it is doubtful if they are represented in this region. The life of this era was abundant, the plants were algæ and seaweeds, the animals, members of the different orders of invertebrate life that live in the sea. No traces of land plants or animals have ever been found. So little is known that it is impossible to form any very definite idea of the conditions existing in this region during Cambrian times, but it is thought to have been the bed of a comparatively shallow sea over which sediments of sand and clay were deposited.

The Lower Silurian Era.—The characteristic rocks of this era are the calciferous sand rock, the Trenton limestone, the Utica and Hudson River or Cincinnati shales. The sand rock does not seem to be represented in Indiana, but the others are surface rocks in several counties of southeastern Indiana and are underlying rocks over the balance of the State. The life of this era as shown by its fossil remains was much like that of the Cambrian, but remains of insects and of fishes indicate considerable progress in the forms of life.

The limestones which make up the principal strata of this era in Indiana seem to have been formed in warm shallow coast waters, the land slowly but surely encroaching on the sea, as in the case of some parts of Florida and Cuba at the present time.

This era closed with the elevation of the Taconic system in the east and the Cincinnati arch in the central regions. The Cincinnati uplift extends from the region of Cincinnati northwesterly across Indiana and northerly through Ohio. It consists of many ridges or folds extending in various directions, which are important features in the geological formations of the State.

The Trenton limestone was originally simple corbonate of lime, but in same localities it has changed to a porous magnesian limestone, which has become a reservoir for mineral oil and natural gas.

The Upper Silurian Era.—The earliest rock of this era is the Medina sandstone, which does not seem to be represented in the central regions. Following this sandstone were the Niagara and Clinton limestones and shales, which extend over the greater part of Indiana. They are surface rocks in Wabash, Miami, Wells, Huntington, Adams, Grant, Blackford, Marion, Tipton, Clark and other counties of eastern Indiana. The life of this era was abundant. The Niagara and Clinton limestones are noted for the number and variety of their fossils. The life was much like that of the Lower Silurian but with more species of insects and fishes. During this era there seems to have been shallow seas with coral reefs and myriads of mollusks, brachiopods, crustaceans and similar forms of life. In some cases there seem to have been extensive mud flats and marshes with turbid waters, so that the forms of life were limited in numbers. In some localities extensive beds of salt were deposited. Portions of the Niagara limestone near Chicago are said to be saturated with rock oil, but it is not generally an oil-producing rock.

The Devonian Era.—The rocks of this era found in Indiana are the Corniferous limestones and Genesee shales. They underlie the northern and western part of the State and are surface rocks in Jefferson, Rush, Jennings, Bartholomew, Decatur, Shelby, Johnson, Tippecanoe, Cass, Wabash, Clark and Floyd counties. In this era land plants, as lycopods, ferns and equisetæ, became abundant, and great fishes dominated the seas; but the conditions were specially favorable to the growth of corals, and the Corniferous limestone is a coral rock, showing that form of life to have been varied and abundant. But during the deposition of the shales the waters were turbid and the forms of life were few. The Corniferous limestone in some localities abounds in mineral oil, as in western Canada. A coarse, porous sandstone of the Upper Devonian is the chief source of the mineral oil and natural gas of Pennsylvania.

The Carbonic Era.—This era is divided into the Subcarboniferous, Carboniferous and Permian periods. The Permian is not represented in Indiana.

The Subcarboniferous Period.—The rocks of this period in Indiana are the sandstones and shales of the Knobstone group, the limestones and shales of the Keokuk group, the famous oölitic limestones, with the shales and other limestones of the St. Louis group, and lastly the sandstones, shales and limestones of the Chester group. The limestones of these groups abound in fossil crinoids, brachiopods and corals, and are often called crinoidal limestones. The famous crinoid beds of Crawfordsville belong to the Keokuk group of strata. These strata indicate shallow seas, sometimes clear and abounding with life, again turbid and nearly devoid of life. These are outcropping rocks in Washington, Orange, Crawford, Brown, Monroe, Harrison, Floyd, Lawrence, Owen, Morgan, Putnam, Benton, Hendricks, Montgomery, Tippecanoe, Perry, Jackson, White and Jasper counties.

The Carboniferous Period.—The rocks of this period in Indiana consist of 13 or 14 coal seams, with their associated sandstones, shales and limestones. These strata are surface rocks in Posey, Vanderburgh, Warrick, Spencer, Gibson, Pike, Dubois, Knox, Daviess, Martin, Sullivan, Greene, Clay, Vigo, Parke, Vermillion, Perry, Owen, Crawford, Fountain and Warren counties.

While carboniferous strata are found in the counties mentioned, the whole series does not occur in any one locality.

The basic rock of the coal measures is generally a coarse-grained sandstone, known as the millstone grit or conglomerate sandstone. This rock is distinct and well marked in Ohio and eastward, but it is often difficult to identify in Indiana. The strata of this period are generally very irregular in their structure and composition, making it a difficult one to work out. In general, it must have been a period in which a great variety of conditions prevailed. The surface was subject to many oscillations. At times the surface of the country was an extensive swamp or morass, over which peat-like sediments were forming. Again the surface was submerged, and mud beds of fine clay were being deposited; or the currents were stronger, and beds of sand were formed; or the waters were clear and crinoids and mollusks abounded, and their remains soon began to form beds of lime sediments.

During the Carbonic era plants were the dominant forms of life. Ferns, equisetæ, lepidodendrids, sigillaria and similar plants were abundant, furnishing much of the material for the coal beds. Among animals, many new species of insects and some higher types of fishes appeared. In addition, amphibians became abundant and a few reptiles appeared.

The Carbonic era and Paleozoic time closed with the elevation of the greater part of the Appalachian Mountains and the raising of the central regions to a permanent position above the sea. The elevation of the central regions was accomplished without any profound disturbance of the strata in this portion of the valley.

There are no rocks in Vigo County or in Indiana belonging to the Triassic, Jurassic or Cretaceous periods. If any sediments were ever formed over this region during these periods they were entirely removed by subsequent erosion.

During the Triassic, Jurassic and Cretaceous periods, which together make up Mesozoic time, sandstone and limestone rocks were formed along the Atlantic coast and in the western mountain regions. There are also some shales and eruptive rocks belonging to these periods. During these periods reptiles became the dominant forms of life. They were numerous, and of large size, and existed in a great variety of forms. And during this time the first birds, the first mammals and the first of our common fishes appeared. Among plants the first palms, the first true pines, and the first angiosperms, like the maple, magnolia and willow, appeared.

During this era the central regions of the continent, covered with vegetation, were slowly wasting away by erosion.

Mesozoic time closed with the elevation of the greater part of the Rocky Mountain system and the raising of the western interior regions of the continent above the sea.

The Tertiary Era.—During this era fragile sandstones and limestones, with some shales, were deposited along the borders of the continent, and in numerous isolated salt-water lakes in the western regions. Certain gravels in southern Indiana may be Tertiary formations, but they are not extensive and their relations are doubtful. Mammals and plants much like those of the present came to be the chief types of life. This portion of Indiana was doubtless covered with vegetation and was the home of many forms of animal life.

The old drainage channels are the only records of the work done during the millions of years that have elapsed since the coal strata were deposited.

These old channels in Vigo County are from 100 to 250 feet deep and occupy fully one-half the area of the county.

They furnish no data for even an approximate estimate of how much of the strata was carried away, but they do indicate that the erosion was very extensive.

The Tertiary era closed with great elevations in the western mountain regions, but with little disturbance in the eastern portions of the continent. Great elevations also took place in Europe and Asia.

The Quaternary Era.—This era begins with the *Glacial Period.* The increased elevation and the enlarged area of the continental surface which marked the close of the Tertiary era, seem to have been important factors in causing the frigid climate of the Glacial period.

This low temperature continued until the ice accumulating over northern regions spread out toward the south, at first following the valleys, then overriding the hills covered the whole area with a mantle of ice.

The ice with its load of clay, sand, gravel and boulders crept slowly over the land, and like a great rasp cut down the more prominent features of the landscape, polishing the rocky surfaces, driving before it all kinds of vegetable and animal life, scraping away the old soils and filling all the old valleys with boulder clay and other glacial debris. The ice reached almost to the Ohio River, crossing it for a few miles near Cincinnati.

When at last the severe temperatures moderated and the ice melted away, the new surface was for the most part a plain. The immense quantities of boulder clay, the glaciated bed rock, and glaciated boulders from the Laurentain and Huronian rocks show that the glacier or ice sheet was in force over Vigo County.

As the ice melted away the streams reopened some of the old channels and made some new ones, but the northern regions seemed to have been slowly depressed, so that the streams became sluggish, and the greater part of the glaciated area was covered with lakes and marshes, conditions similar to those of the Carbonic era. This period called the *Champlain Period* was closed by a slight elevation, which raised the interior region to its present altitude and slope; drainage systems were developed and the Recent or Present Period of the earth's history with its modern vegetation and mammalian life was inaugurated.

The following table is a conservative estimate of the age of the earth and of the relative length of the different eras. It was compiled from the writings of Professors James D. Dana and Charles Wolcott:

The Quaternary Era	1,000,000	years.
The Tertiary Era	2,000,000	“
The Cretaceous Period	3,000,000	“
The Jurassic and Triassic Periods	4,000,000	“
The Carbonic Era	2,400,000	“
The Devonian Era	2,000,000	“
The Upper Silurian Era	1,600,000	“
The Lower Silurian Era	6,000,000	“
The Cambrian Era	6,000,000	“
The Later Archean Era	18,000,000	“
The Early Archean Era	18,000,000	“

THE STRATA OF VIGO COUNTY.

The strata which outcrop in the county or are easily reached by mining shafts belong to the Carboniferous period. These strata consist of coals, sandstones, shales, sandy shales and limestones. Each stratum varies in composition and thickness, and those near the surface were extentively eroded and furrowed with broad and deep channels during the millions of years that measure mesozoic and cenozoic times. At the close of the Glacial period these valleys were filled with boulder clay, and in many cases the hills were covered with a thick mantle of the same material. By subsequent erosion much of the boulder clay was carried away, and some portions replaced by sand and gravel. These circumstances make it difficult to trace the upper strata with any degree of certainty.

The strata of the other periods, down to and perhaps including the Huronian, lie in order below, but the records of the deep wells that have been drilled in the county are somewhat contradictory, and there is no very definite knowledge of such lower strata. The strata generally dip gently toward the west and perhaps toward the south, the general dip being often obscured by local variations which are often quite abrupt. On account of the westerly dip of the rocks of Vigo County the uppermost strata are on the west of the river. The following is a somewhat generalized section of the strata of the county:

Surface soil and subsoil clays	10	feet.
Boulder clay, or hard pan	20	feet.
Shale, with some sandstone	50	feet.
Sandy shales and clay shales	25	feet.
Limestone, variable, sometimes shaly	1	foot.
Shale, laminated, friable	1	foot.
Coal, rider vein, No. 9 (?) Illinois section	1	foot.
Fire clay and shale with limestone seams	12	feet.

Limestone, sometimes stratified with shale	3 feet.
Shale, argillaceous, fine	30 feet.
Coal, "O" Indiana sec.; No. 8 (?) Illinois sec.	4 feet, 6 inches.
Fire clay and shale	10 feet.
Limestone, massive, sometimes flinty	3 feet.
Shale, gray or reddish	10 feet.
Limestone, flinty, sometimes massive	3 feet.
Sandstone, massive or shaly	15 feet.
Shale, argillaceous, with some iron stone	20 feet.
Coal "N" Indiana sec.; No. 7, Illinois sec	5 feet.
Fire clay and shale, sometimes sandstone	15 feet.
Limestone, often flinty	3 feet.
Shale, black, slaty bituminous	5 feet.
Coal, "M" Indiana; No. 6 Illinois	4 feet.
Fire clay and shale	3 feet.
Sandstone, friable	40 feet.
Coal "L" Indiana; No. 5 Illinois	6 feet.
Fire clay and shale	20 feet.
Coal, outcrop on Otter Creek	2 feet.
Fire clay and shale	20 feet.
Coal, outcrop near county line	3 feet.
Fire clay and shale	15 feet.
Coal, upper vein at Caseyville, Clay County	3 feet.
Fire clay and shale	28 feet.
Coal, middle vein at Caseyville	3 feet, 6 inches.
Fire clay and shale	25 feet.
Coal, lower vein at Caseyville	3 feet, 6 inches.

The strata mentioned outcrop in the county, or are so near the surface that they could be easily reached if they were valuable.

In 1865 Chauncy Rose commenced drilling a well near the northwest corner of Eighth street and Wabash avenue, Terre Haute. The well was drilled for the purpose of obtaining fresh water, but after reaching bed rock at about 130 feet no fresh water was found. They found salt water in abundance. At 1,630 feet they found mineral oil, and at 1,793 feet they encountered a strong flow of sulphur water. Later a well was drilled on the northwest corner of Cherry and Eighth streets with about the same results as in the first case, and the sulphur water was used to supply a bath house. Later a third well was drilled near Wabash avenue, on the alley between Ninth and Tenth streets. This well is said to have yielded a strong show of mineral oil. Before 1870 a fourth well was drilled expressly for oil. It was located near the river, between Walnut and Poplar streets, Terre Haute. The following is a record of the strata passed through, as given in the Report of 1870 and again in the Report of 1875:

Section commencing about 20 feet above low water in the river:

			Total	
	Ft.	In.	Ft.	In.
Sand and gravel	100	00	100	00
Soapstone	64	06	164	06
Coal "I"	6	02	170	08
Hard sandstone	2	03	172	11
Soapstone	10	00	182	11
Coal "G"	3	00	185	11
Soapstone	4	03	190	02
Gray sandstone	5	10	196	00
Blue soapstone		10	196	10
Gray sandstone	6	00	197	04
Blue soapstone	12	09	210	01
Soft black shale	6	00	216	01
Coal "F"		09	216	10
Soapstone	7	07	224	05
White sandstone (conglomerate?)	30	03	254	08
Salt Water from this Sandstone.				
Blue Shale	7	02	261	10
Coal "B"	2	03	264	01
Black shale	10	00	274	01
White soapstone	3	00	277	01
Black shale	15	00	292	01
White soapstone	8	00	300	01
Black shale	3	03	303	04
Coal "A"	3	00	306	04
Soapstone	17	08	324	00
Sand rock	3	00	327	00
Soapstone	20	00	347	00
Sand rock	10	00	357	00
Blue shale	22	00	379	00
Limestone	2	00	381	00
Blue shale	31	00	412	00
Light shale	5	00	417	00
Blue shale	60	00	477	00
Sandstone	7	00	484	00
Blue shale	24	00	508	00
Sandstone	3	00	511	00
White shale	10	00	521	00
Blue shale	147	00	668	00
Hard gritty slate rock	11	07	679	07
Hard gray sandstone	14	05	694	00
Hard limestone	11	00	705	00
White limestone	24	00	729	00
Gray limestone	2	00	731	00
Limestone	14	00	745	00
White limestone	82	00	827	00
Soapstone	3	00	830	00
Brown limestone	35	00	865	00

			Total	
	Ft.	In.	Ft.	In.
Soapstone	5	50	870	00
Lime rock	9	00	879	00
Soapstone	6	00	885	00
White limestone	7	00	892	00
Soapstone or gypsum?	2	00	894	00
White limestone	21	00	915	00
Gray limestone	5	00	920	00
Limestone and soapstone	5	00	925	00
Gray limestone	5	00	930	00
White limestone	15	00	945	00
Fine blue limestone	2	00	947	00
STRONG SULPHUR WATER.				
Dark gray limestone and flint	73	00	1,020	00
Light gray limestone	7	00	1,027	00
Blue gray limestone	7	00	1,034	00
Soapstone (fire clay)	26	00	1,060	00
Gray limestone	24	00	1,084	00
Gray sandstone	3	00	1,087	00
Soapstone (fire clay)	5	00	1,092	00
Quartz and shale, mixed	166	00	1,258	00
Quartz, slate and soapstone	3	00	1,261	00
Slate rock	21	00	1,282	00
Soapstone	33	00	1,315	00
Slate rock	7	00	1,322	00
Soapstone	235	00	1,557	00
STRONG SALT WATER AT 1,557 FEET.				
Soapstone and sandstone	10	00	1,567	00
Fine sandstone	15	00	1,582	00
Blue soapstone	40	00	1,622	00
Black shale	15	40	1,637	00
Red shale	5	00	1,642	00
OIL.				
Black shale	15	00	1,657	00
OIL.				
Lime rock	5	00	1,662	00
Black shale	5	00	1,667	00
OIL.				
Gray lime rock—OIL NEAR THE TOP	149	00	1,816	00
SULPHUR WATER AT ABOUT 1,800 FEET.				
Gray sand rock	23	00	1,839	00
Lime rock	73	04	1,912	04
SULPHUR WATER AT 1,840 AND 1,912 FEET.				

Professor Cox says that "experienced borers were employed, and the record of the strata passed through may be relied upon as accurate. The record has been carefully made, and each layer of rock tested to determine its character, consequently the sandstones are correctly placed."

Later the gas company drilled a well for gas on the bank of the river, near the foot of Swan street, Terre Haute. The record of this well, kept by Martin N. Diall, superintendent, is as follows:

	Ft.	Total Ft.
Sand and gravel, sandstone, shale and limestone	1,110	1,110
Limestone	450	1,560
Shale	50	1,610
Limestone	3	1,613
To Oil Sands and Oil.		
Limestone	967	2,580
Shale	100	2,680
Limestone (perhaps Trenton)	250	2,930

Some of the wells drilled for water yielded oil, and some gas, but no measures were taken to promote the flow of either, and the well that seems to have furnished the most oil was plugged up and the site is now covered with buildings. The wells drilled for oil and gas yield an abundance of salt water and sulphur water, but no oil and but little gas.

In 1888 a wave of oil excitement reached Terre Haute and several wells were drilled for oil or gas. The records of the strata passed through in the drilling vary widely in detail, but agree in a general way, so that the ideas gained from a study of several different records will give a better knowledge of the deep strata of Vigo County than could be gained from one record.

The following records have been reduced to the level of low water in the river by subtracting fifty feet, as they all commenced at about that elevation above the river.

SECTION OF THE KINSER WELL.

Located between Fourteenth and Fifteenth streets just east of the center of section 22–12–9, near Liberty avenue.

			Total.	
	Ft.	In.	Ft.	In.
Soil, gravel and sand	130	00	80	00
Shale or soapstone	70	00	150	00
Sandstone	10	00	160	00
Shale or soapstone	90	00	250	00
Sandstone	70	00	320	00
Shale or slate	130	00	450	00
Sandstone	140	00	590	00
Limestone	360	00	950	00
Limestone, with some shale	185	00	1,135	00
Limestone, with some quartz	85	00	1,220	00
Shale or soapstone	25	00	1,245	00
Limestone, with shale	225	00	1,470	00
Shale or soapstone	5	00	1,475	00
Sandstone or limestone	15	00	1,490	00
Shale or soapstone	138	00	1,628	00
Limestone or oil rock	20	00	1,648	00

A Little Oil Near the Surface of this Limestone.

SECTION OF THE BIG FOUR WELL,

In the northeast corner of the northwest quarter of Sec. 23-12-9:

			Total.	
	Ft.	In.	Ft.	In.
Soil	6	00	....	..
Gravel	10	00	....	..
Sand	102	00	68	00
Shale or soapstone	117	00	185	00
Sandstone or limestone	2	00	187	00
Shale or soapstone	207	00	394	00
Salt Water at 265 Feet, 78 Feet Below Top of this Shale.				
Limestone or sandstone	41	00	435	00
Shale or slate	50	00	485	00
Limestone or sandstone	12	00	497	00
Shale or slate	53	00	550	00
Sandstone	50	00	600	00
Limestone	600	00	1,200	00
Shale, with some limestone	190	00	1,390	00
Shale or slate	210	00	1,600	00
Limestone, oil rock, sulphur water	18	00	1,618	00

SECTION OF THE EXCHANGE WELL,

Situated a little west of the center of Sec. 22-12-9:

			Total.	
	Ft.	In.	Ft.	In.
Soil and coarse gravel	80	00	30	00
Sand, fine	45	00	75	00
Shale and slate	65	00	140	00
Coal at 88 Feet Below Low Water in River.				
Limestone	5	00	145	00
Shale	95	00	240	00
Limestone	10	00	250	00
Shale	40	00	290	00
Limestone	20	00	310	00
Shale or soapstone	210	00	520	00
Limestone	23	00	543	00
Shale	10	00	553	00
Limestone, hard and flinty	82	00	635	00
Shale	5	00	640	00
Limestone	160	00	800	00
Limestone, with some sand	70	00	870	00
Sandstone	30	00	900	00
Limestone	25	00	925	00
Sandstone	65	00	990	00
Limestone	30	00	1,020	00

Shale and slate	180	00	1,200	00
Sandstone, white	50	00	1,250	00
Sandstone and shale	50	00	1,300	00
Sandstone, white	150	00	1,450	00
Shale and slate	122	00	1,572	00
Limestone—oil rock	11	00	1,583	00

SHOW OF OIL AT 1,575 FEET, AND SULPHUR WATER AT 1,578 FEET.

SECTION OF THE ALDEN WELL,

On the northwest quarter of Sec. 23–12–9:

			Total.	
	Ft.	In.	Ft.	In.
Sand and gravel	130	00	80	00
Shale or soapstone	110	00	190	00
Limestone	20	00	210	00
Shale or slate	300	00	510	00
Sandstone	10	00	520	00
Shale or slate	30	00	550	00
Sandstone	160	00	710	00
Limestone	300	00	1,010	00
Sandstone	90	00	1,100	00
Shale or slate, with some sand	132	00	1,232	00

SALT WATER IN THE SHALE AT 525 FEET, AND SALT WATER AND SULPHUR WATER BETWEEN 600 AND 700 FEET.

SECTION OF THE ELLIOTT WELL,

Located near the west line of Sec. 23 and Wabash avenue, Terre Haute:

			Total.	
	Ft.	In.	Ft.	In.
Sand and gravel	128	00	78	00
Shale or soapstone	260	00	338	00
Sandstone	35	00	373	00
Limestone	40	00	413	00
Sandstone	98	00	511	00
Limestone	23	00	534	00
Sandstone	179	00	713	00
Shale or slate	110	00	823	00

In the *Smith Well*, near the southwest corner of Wabash avenue and Tenth street, S. W., S. W., sec. 22–12–9, they found shale at 112 feet, or at 62 feet below low water in the river, and the oil rock, limestone, at 1,632 feet, or at 1,582 feet below the river.

In the *Guarantee Well No. 3*, located between Eighth and Ninth streets, near Wabash avenue, the shale was found at 84 feet below low water, the first heavy limestone at 537 feet, top of the "oil sand" limestone at 1,569 feet, which rock was penetrated to 1,577 feet and 3 inches.

In the *Guarantee Well No. 4*, located on Tenth-and-a-Half street between Wabash avenue and Chestnut street, shale was found at 85 feet below low water, and a vein of coal six to seven feet thick at 305 feet, and blue lick or sulphur water at 1,590 feet.

In the *Guarantee Well No. 5*, near southwest corner South Fifth street and Farrington street, on the S. E. ¼, N. E. ¼ Sec. 28-12-9 shale was found at 106 feet below low water, and the top of the first limestone at 700 feet, the top of the "oil sand" limestone at about 1,700 feet, which was penetrated about 22 feet.

SECTION OF GUARANTEE WELL No. 6.

Northeast corner of Third and Mulberry streets, N. W. ¼, S. E. ¼ Sec. 21-12-9:

			Total.	
	Ft.	In.	Ft.	In.
Soil, gravel and sand	128	00	78	00
Shale of varying shades	44	00	122	00
Coal, apparently good quality	5	00	127	00
Shales and sandstones	308	00	435	00
Limestone	40	00	475	00
Shales, blue and black	90	00	565	00
Limestone, varying somewhat	415	00	980	00
Very Strong Salt Water at 800 Feet. Gas Strong Between 925 and 935 Feet.				
Limestone, coarse	25	00	1,005	00
Shales, with some limestone	55	00	1,060	00
More Gas at 1,060 Feet, Pressure Very Strong.				
Shales, with some limestone	40	00	1,100	00
More Gas at 1,100 Feet.				
Limestone, with some shales	320	00	1,420	00
Shales	25	00	1,445	00
Limestone	9	00	1,454	00
Shale	43	00	1,497	00
Black shale with limestone shells	72	00	1,569	00
Coarse shales	9	00	1,578	00
Black limestone rock	20	00	1,598	00
Blue Lick or Sulphur Water at 1,598 Feet.				

S. M. Reynolds, who superintended the drilling, says the Niagara limestone was well defined at the depth of 1,592 feet.

SECTION OF AN ARTESIAN WELL

Drilled at St. Mary's on the N. E. ¼, S. W. ¼ Sec. 6–12–9, by "The Sisters of Providence,'" the mouth of the well being about 100 feet above low water in the Wabash River:

			Total.	
	Ft.	In.	Ft.	In.
Surface soil and yellow clay	20	00	....	...
Blue clay	55	00	....	...
Blue clay and quicksand	25	00	Low water.	
White shale	25	00	25	00
Coal, probably coal "N"	5	00	30	00
White shale—fire clay and shale	65	00	95	00
Coal, probably coal "M"	6	00	101	00
White shale—fire clay and shale	90	00	191	00
Coal, probably coal "L," the big vein	10	00	201	00
Fire clay and white shale	50	00	251	00
White sand rock	40	00	291	00
White shale	229	00	520	00
Sandstone	80	00	600	00
Limestone	490	00	1,090	00
FRESH WATER AT 730 FEET.				
Shale	50	00	1,140	00
Brown sandstone	20	00	1,160	00
White shale	250	00	1,410	00
Limestone and sandstone	180	00	1,590	00
Brown shale	115	00	1,705	00
Limestone	250	00	1,955	00

Sulphur water at 1,905 feet, but no show of oil or gas reported.

These different wells were drilled for water, oil or gas, and not for coal, nor for scientific purposes, consequently little attention was given to coal seams, or to an accurate record of the strata passed through.

The ordinary plunger drill was used so that the materials passed through in a distance of from five to seven feet were in general well pulverized and thoroughly mixed, making it difficult to mark the division between strata with accuracy, and often it was impossible to judge of the nature of the rock beyond the fact that it was easy or difficult to drill. The measurements were generally made by the rope, which, as the depth increased, became more and more uncertain. The strata are doubtless also more or less irregular, and mistakes may have been made, so that wide discrepancies are to be expected. Prof. E. T. Cox says that "in the record of the first well or bore given in the report of 1869 a number of limestones are represented in the upper part of the bore where none occur, and the lower carboniferous limestone, over three hundred feet thick, is almost entirely represented by shales." In the Seventh Report, after giving the record of the river well, Prof. E. T. Cox says: "It is of course difficult to decide with certainty on the correlation of strata of coal when no other means are furnished than the simple record of a bore kept by parties who possess but a limited knowledge of the specific characters of rocks, even when exposed to view at the surface, much less when brought up by the sand pump in the condition of fine sediment.'' These remarks apply to many of the records made, but in some cases samples were preserved and measurements were made with a steel tape line, and in some cases the record keeper knew how to test for limestone. The wells all enter shale below the gravel and sand. This shale, having the irregularities of an old river bed, accounts in the main for the varying thickness of the gravel. The record of Guarantee No. 5 seems to indicate a dip of the strata toward the south. The river well shows shale 64 feet, coal 6 feet 2 inches, and shows four other veins within 125 feet. The Guarantee No. 6 shows shale 44 feet to coal 5 feet 8 inches, but shows no coal below. The Guarantee No. 4 shows coal 6 feet 120 feet below the top of the shale, but no coal below. Coal is mentioned in the record of the Alden well, but no definite record was made. I can find no other mention of coal, so that I think the details of the river well record concerning coal may be taken with grains of allowance. Nearly all the wells pass through a heavy bedded limestone, which they reach at different depths as follows:

The Guarantee No. 3 at	537	feet.
The Exchange Well at	553	"
The Guarantee Well No. 6 at	565	"
The Kinser Well at	590	"
The Big Four Well at	600	"
The well at St. Mary's at	600	"
The well by the river at	665	"
The Guarantee No. 5 at	700	"
The Alden Well at	710	"

This limestone varies from 300 to 500 feet in thickness and is often, perhaps generally, interstratified with shales, which practically divide it up into numerous strata, which doubtless represent the subcarboniferous limestones which are surface rocks in Putnam, Monroe and other counties to the east of the coal belt.

At about 200 feet, just below coal "F," the record of the river well shows 30 feet of sandstone, which Professor Cox thinks represents the millstone grit or conglomerate. The Kinser Well reaches 70 feet of sandstone, at 250 feet, but none of the other records show a corresponding sandstone, so that the millstone grit does not seem to be very well defined in this county.

The next place at which the records substantially agree is the top of the limestone in which oil was found. The records are as follows:

Guarantee Well No. 3, limestone, at	1,569	feet.
Exchange Well, limestone, at	1,572	"
Guarantee Well No. 6, limestone, at	1,578	"
The Smith Well, limestone, at	1,582	"
Guarantee Well No. 4, limestone, at	1,590	"
The Big Four Well, limestone, at	1,600	"
The Kinser Well, limestone, at	1,628	"
The Riverside Well, limestone, at	1,627	"

And all agree in recording something over 100 feet of shale as resting upon this limestone. To what age does this rock belong? This is confessedly a difficult question to answer. Some have thought it Trenton limestone, assigning the Niagara to a place about 700 feet below the surface. Some have called it corniferous limestone, and others think it is the Niagara limestone.

In the report of 1881 the general section of the State is given as follows:

Coal Measures	725	feet.
Sub-Carboniferous	680	"
Devonian	200	"
Silurian	3,000	"
Total	4,605	feet.

A careful study at the present time might suggest some changes in this section, yet it makes it almost certain that the limestone can not be the Trenton rock.

Professor E. P. Cubberly, in "Indiana's Structural Features as Revealed by the Drill," Eighteenth Report, pages 219 and 223, calls the shale Devonian and the limestone Niagara. The shales are undoubtedly Devonian, but it is not clear why the limestone may not as well be referred to the Corniferous as to the Niagara. The river well shows oil in the upper portion of a limestone 150 feet thick, then 23 feet of sandstone, then another limestone. The Gas Works well record shows continuous limestone from the oil horizon to 2,500 feet, and the Exchange well deepened to 1,800 shows continuous limestone.

The Corniferous limestone belongs and often occurs between the Devonian shales and the Niagara limestones, but it is sometimes absent. There are three records below the oil horizon, of these the gas well record is, I think, the most reliable. The balance of the evidence shows continuous limestone, and continuous limestone would, I think, indicate Niagara rock. Practically the question is not of much importance, as oil has been found in paying quantities in both the Corniferous and the Niagara limestones.

OIL.

On the 8th of May, 1888, mineral oil was reached in the Diall well, Guarantee No. 1. It is located on the alley between 9th and 10th streets and between Chestnut and Eagle streets. It came in a gusher, and it was a surprise. Oil flowed out over the whole region into the sewer and down to the river and its villainous odor filled the air for squares. The excitement was intense. Oil and gas companies were formed by dozens. Hundreds of localities were leased and soon a score of drills were pounding downward toward the oil-bearing rock. The Phenix well, between Mulberry and Eagle streets, reached the oil and has been a good well ever since. The Lewis well, Guarantee No. 3, between 8th and 9th streets near Wabash avenue yielded some oil, but most of the others got only salt water and blue lick or sulphur water. The Phenix well is now producing about 1,800 barrels of oil per month. The oil flows but slowly and the output is increased by continuous pumping. This seems necessary to keep back the water. The Guarantee No. 1 has been drowned out, but a few days or weeks of pumping would doubtless make it again an oil well as strong as ever.

The fact that even one well is now yielding oil, and has been a strong well for nearly eight years, is conclusive evidence of an oil field. But how extensive it is no one can tell. The Phenix well has been deepened a few feet from time to time for the purpose of facilitating the flow of the oil. Such a large product for so many years is a remarkable record among oil wells.

The longer this well continues to yield oil in abundance, the stronger grows the conviction that the oil field is of considerable extent. But where is it? The Diall well, Guarantee No. 1, on Nine-and-a-Half street near Chestnut; the Phenix well about 300 feet due south; the Lewis well, Guarantee No. 3, between Eighth and Ninth streets, near Wabash avenue, and the Rose well on Nine-and-a-Half street, near Wabash avenue, seem to be in the field. The Lewis and the Diall wells have each produced from 700 to 1,000 barrels of oil per month, and if pumped continuously would probably yield as much now as ever before. The Exchange well, about 500 feet east of the Diall well; the Guarantee No. 2, on Eighth street, about 1,000 feet north and a little west; the Smith well, due south near Wabash avenue, found only salt water and sulphur water. Nine or ten other wells in different directions from the producing wells, but at greater distances, found the sulphur water and not the oil. It hardly seems possible so small an area as that occupied by the producing wells could have supplied these wells for so many years. Mr. Diall suggests that these wells reached a small area of producing rock that is connected with a much larger field by a narrow passage, but no one has any idea of the location of the larger field. The oil is generally found in or near anticlines. The records of the wells drilled give some indications of a slight anticline trending north and south, but slight differences in level and imperfect measurements make it impossible to establish or demonstrate an anticline with any degree of certainty. There are three well-marked anticlines in the southern portion of the county which might yield some oil if explored with a drill.

Natural Gas.—In each of the wells drilled more or less gas was found, in some cases under very strong pressure. In Guarantee No. 6 a strong flow of gas was met at 975 feet. The pressure was sufficient to throw out the whole column of salt water, and, when lighted, burned with a flame ten to twelve feet high. This pressure continued for several days. At the Bath House well, near the river, the gas was for a long time used as a fuel. In most cases the sulphur water flowed from the well. Before reaching gas, water stood in the wells at about the level of the river. In some cases, at least, the water began to flow after the gas was found, and many ascribe the flow of the water to the pressure of the gas, others think the water-flow was caused by hydrostatic pressure, possibly from the Great Lakes. Mr. S. M. Reynolds, who has given the matter considerable attention, thinks the water-flow is due to gas pressure.

THE OUTCROPPING STRATA OF VIGO COUNTY.

The uppermost rock stratum in Vigo County is a thick bed of bluish shale, which outcrops along Coal Creek and its branches in sections 14, 15 and 23, T. 13 N., R. 10 west, and along West Little Sugar Creek, in sections 9, 10 and 15, T. 12 N., R. 10 west. In each of these localities it forms cliffs from 20 to 40 feet high.

In Sugar Creek Township this shale weathers into concretionary masses. There is no appreciable difference in the hardness of the successive shells of the concretion, nor does the nucleus seem to be harder than the rest. P. J. Ryan sunk a well forty feet into this bed on N. E. ¼ of the N. E. ¼ section 9, 12–10. The material thrown out had the ordinary shale fracture, and in appearance was like the common shales of the coal measures. But after it had been exposed to the weather for several weeks every lump became a concretion, breaking up easily into spherical shells. The bed seems to be fine aluminous shale, growing a little sandy toward the surface, as shown in Mr. Ryan's well. Just north of the well I found some micaceous sandstone in a little creek bed, but I could get no idea of its thickness or extent. I think it is only a thin layer of no great extent, with shale above and below.

Along Coal Creek the shale on the weathered face has a jointed structure, and is a very fine quality of shale for manufacturing purposes. On section 15 there are some thin layers of sandstone in the shale, which one mile south, on sections 22 and 23, have thickened up into a bed of compact sandstone, from three feet to five feet in thickness. On the S. E. N. E. section 22, and near the middle of the N. W. ¼ section 23, this rock has been quarried to some extent for use in foundations for houses and barns in the neighborhood. Some has been used for bridge piers. Mr. H. T. Carson, who has done most of the quarrying, says the rock in some cases has stood well for forty years as foundation stones, but that it is too porous for bridge work. The compact stone is really of limited extent. Between the two quarries the bed consists of sandy shales. I could find no trace of this sandstone west of section 22 or east of section 23, and none north of section 15. None appears toward the south unless that found near Mr. Ryan's, on S. W., S. W., section 4, 12–10, may be an extension of the bed. On S. E., S. W., section 14, 13–10, I could find no trace of it in a high shale bluff. This body of sandstone seems worthy of mention, but whether it is entitled to be regarded as one of the strata of Vigo County is doubtful. Below the sandstone the shale is apparently the same as that above. The thickness of the bed along Sugar Creek is at least fifty feet, and on Coal Creek, including the sand, stone, it has the same thickness.

Along Ashmore Creek and its branches, on sections 30 and 31–11–10, and along Crooked Creek, on sections 17 and 20–11–10, in Clark County, Illinois, there is an outcrop of sandstone, limestone, shale and coal, as follows:

Sandstone, reddish, compact or shaly	50 ft. + or —
Sandstone, shaly, with thin partings of coal	2 ft.
Shale, gray, free from grit	2 ft.
Limestone, massive, many fossils	2 ft.
Shale, dark colored	2 ft.
Shale, slaty, splitting into broad sheets	2 ft. + or —
Coal, apparently of good quality	1 ft. 6 in.
Fire clay and shale	5 ft. + or —

Some of the limestone was clayey, but seemed to resist well the action of the atmosphere, weathering evenly on the outcrop. The slaty shale in some places was interstratified with thin layers of coal, and the layers were in many cases covered with gypsum crystals. The sandstone on Ashmore Creek forms cliffs of beautiful dark-brown stone, that is uniform in texture and color. The coal is called No. 10 in the Illinois section * These strata rise rapidly toward the north and are not to any extent represented in our county, except the shale below the coal, which, I think,

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*See Vol. VI, pages 18 and 19, of the Illinois Reports.

is the upper stratum of our county outcropping along Coal Creek and West Little Sugar Creek. These strata enable us to correlate the strata of Vigo County with those of Illinois.

In the bank of Coal Creek, on S. E., S. W., Sec. 14–13–10, below the shale there is a thin bed of limestone that varies in thickness and character. The strata in that locality are about as follows: Shale, 30 feet + or —; limestone, 6 inches; shale, somewhat slaty, 6 inches; coal, 1 foot 3 inches; fire clay and shale, 2 feet; a very white shale, free from grit and with the taste of alum, 2 feet; shales, seamed with limestone in various directions, 2 feet +.

The limestone above the coal was sometimes blue, compact and hard, but within a quarter of a mile it appeared like limestone nodules cemented with clay. In section 23, a half mile south, it was represented by a calcareous shale. The coal on section 23 is not more than six inches thick, but on N. E., S. W. section 24 it is about 1 foot 3 inches again. I did not find this vein anywhere outside the Coal Creek Valley, and whether it is a local vein of limited area or whether it represents the Illinois No. 9 I can not tell. It has been worked a little, both on sections 14 and 24, and the coal is said to be of good quality, but the vein is too thin for profitable working. The white shale that tasted of alum was peculiar and interesting. I have seen nothing else like it in the county. It seems to be of limited extent, but a little exploration might disclose it in large quantities.

On the N. E. quarter, N. W. quarter section 23–13–10, Messrs. Eddington and Vermillion have a coal shaft which passes through the following strata; commencing in the valley below the sandstone:

	Ft.	In.
Shale, light colored, fine quality	5	00
Limestone, impure and shaly	0	06
Coal, of inferior quality (Illinois No. 9)	0	08
Shale, of good quality	34	00
Limestone, clayey	8	00
Shale	34	00
Coal, Indiana "O," Illinois No. 8	4	08

This coal is the main vein in Fayette Township, along Coal Creek, and north to Brouilett's Creek. The strata above it, or between it and No. 9, vary somewhat, but in general are as given in the section of the shaft on section 23. Along Coal Creek, as shown in its banks and bed, the limestone is very irregular in bedding and character. In general it is interstratified with the shale sometimes in nodular masses of flinty limestone, sometimes shaly and jointed. But on the N. W. quarter, S. W. quarter, section 20, the limestone is close grained, compact, somewhat clayey and about 3 feet 6 inches thick. Along Coal Creek the shale, where free from limestone, is of the finest quality. On section 20 there is about 30 feet of shale between the limestone and the coal, while on the S. E. quarter, section 24, there is not more than 15 feet, the limestone being distributed throughout the middle two-thirds of the space between the coals. This shale, and sometimes the limestone, crops out along the streams northward into the valley of Brouilett's Creek.

Coal "O" varies from 3 feet to 5 feet in thickness. It has a roof of good solid shale. Between the shale and the coal there is from 8 to 12 inches of slate or bone coal which consists of layers of slate or shale and coal, the shale having a ribbed or striated appearance. The coal proper is solid without slate or dirt bands, and while there is some sulphur it usually occurs in such masses that it is easily removed. This crops out and has been mined on S. W. quarter Sec. 33–13–9; on N. W. quarter, N. E. quarter Sec. 32; on N. W. quarter Sec. 29; on S. E. quarter Sec. 24–13–10; on S. W. quarter Sec. 20–13–9, and at other points along Coal Creek and its tributaries. The mining has mostly been strip bank or slope mining. This vein has also been mined on S. E. quarter Sec. 17–13–9; on S. W. quarter Sec. 4–13–9, and on the N. E. quarter Sec. 6–13–9, and at several points along Brouilett's Creek and its branches just outside our county. The mining is on a limited scale and almost exclusively for local trade. There is a thin vein of coal outcropping near the center of section 23–12–10, and at other places in Sugar Creek Township. The miners call it the Rider vein. I think it probably is coal "O." It is seldom more than one foot in thickness, and while of good quality is of little economical importance.

Below coal "O" we find fire clay and shale, limestone, shale, sandstone and limestone, sandy shales and clay shales to coal "N." The fire clay and shale on Coal Creek and northward is from six to ten feet in thickness. Toward the south the variation in thickness is through a wider range. In every place that I have been able to examine this material it has been a fine clay shale free from grit. In a bluff of Coal Creek on the S. W., N. W., Sec. 28–12–9, in the lower part of this shale there is a thin layer of fine grained silicious rock about one foot in thickness. It is light brown in color and is traversed by tubes of varying size that possibly may have been worm tubes. It seems to be of limited extent. The limestone along Coal Creek and northward is flinty and nodular, often brittle, and breaking with a conchoidal fracture. It varies from one to two feet in thickness. On the S. half, S. E., Sec. 17–13–9 this limestone changes into a peculiar conglomerate mass of limestone, coal, kaolin, clay iron stone, occurring sometimes as pebbles, again as angular masses, and sometimes as a cement. In one locality this conglomerate seemed to pass into sandy shale filled with kaolin nodules. I did not find this peculiar conglomerate representing the limestone at any other locality west of the river. Toward the south this limestone becomes a hard, somewhat crystalline rock from two to three feet in thickness. It has been quarried on sections 24 and 25–12–10, and quite extensively on N. W. quarter Sec. 15–11–10. It was used in the construction of the old National road, for bridge piers and road bed, and has been used for foundations and riprapping, for which it seems well adapted. It contains a few fossils, but the rock is so hard that it is seldom possible to get out a fossil in good condition.

The shale below this limestone is from three to twelve feet thick, resting usually on limestone below. This is a fine clay shale, generally free from impurity of any kind, but sometimes it is seamed with limestone, sometimes it is reddish or bluish, sometimes white or gray.

In Fayette township, where examined, it was of a light color. On Sec. 23–12–10, and on the S. W. Sec. 11–11–10, it is light colored, but on S. half Sec. 25–12–10, and on the E. half Sec. 15–11–10, and at other places it is highly colored, but always of a fine quality. The shale from H. T. Thorp's place, Sec. 23–12–10, belongs to this bed. It is mentioned in the 20th Report Indiana Geol. Surv. page 73. Near the center of Sec. 23 the two limestones outcrop in the bank of Sugar Creek, and are separated by twelve feet of this valuable shale. But about a quarter of a mile west the limestones outcrop again with not more than three feet of shale between them, and this containing quantities of limestone, generally in boulders. The boulders were of blue fossiliferous limestone, the fossils prominent on the eroded surfaces. The boulders contained masses of calcite, which often formed beautiful crystalline cavities.

The lower limestone varies greatly. In the southern part of the county it is seldom as thick and never of as good quality as the upper one and is called by the miners "bastard limestone." As it forms a thin layer over the sandstone below, they sometimes fail to recognize it as limestone. On Secs. 5, 7 and 18–12–9, both limestones become nodular and irregular in stratification, but on Sec. 33–13–9 the bedding becomes distinct, but the upper is nodular and flinty, while the lower is tough and compact, forming a good building stone. It has been quarried on S. W. Sec. 33 and on N. W. Sec. 28 and on S. W. Sec. 16–13–9. In some places it forms distinct strata, while in others it occurs as great lenticular masses in the sandstone, which usually lies below it.

The sandstone below this limestone is sometimes massive and of uniform texture, forming a good quarry stone, as on S. W. 28, N. W. 28, and S. W. 16–13–9, but toward the south it is fragile and shaly. It merges into a sandy shale which sometimes has a peculiar wavy structure. These sandy shales merge into fine clay shales below, so that it is difficult to say how much there is of either of the three strata below the limestone. Perhaps the following section on Sec. 24–12–10 will be about an average. Sandstone, 12 feet; sandy shale, 10 feet; clay shale, 30 feet. This sandstone and the underlying shales are represented on the east side of the river forming the upper strata over much of the uplands. But on the east side there is less of the sandy shale, the division between the sandstone and clay shale being usually quite distinct. They occur in the southwest of Pierson Township, where the shale disappears so that the sandstone rests on coal "N." In the northwest of Pierson and northeast of Linton Townships, both strata are well developed, the sandstone with some shale bands being thirty feet in thickness and the shale fully as thick. They occur in Riley, Lost Creek and Nevins Townships in the higher elevations. The sandstone and shale outcropping along Stone Quarry Creek belong to these strata, and occasional masses of limestone in the sandstone seem to represent the overlying limestone. I also think the rocks along the old canal near the town of Lockport belong to these strata. The limestone, sandstone and shale on the N. W. quarter Sec. 2 of Riley Township and the sandstone on S. E. quarter Sec. 26 of Lost Creek Township, probably lie just above coal "N," and the same seems to be true of the sandstone and shale on the N. half of Sec. 13, of Honey Creek Township. The following is a section of the Burke Bros. shaft on the S. E. quarter S. W. quarter Sec. 21–12–8, Lost Creek Township.

Surface soil, white and yellow clay	10 feet.
Hard pan or conglomerate	55 feet.
Sand rock, shaly	25 feet.
Coal "N"	5 feet.

A section of the Lochner Coal Company's shaft on N. W. quarter section 14, near Seelyville, is as follows.

Surface soil, white and yellow clay	13 feet.
Hard pan, boulder clay	4 feet.
Sandstone, with black seams	22 feet.
Coal "N"	3 feet.

A portion of the sandstone was like the conglomerate found on S. W. quarter Sec. 16–13–9, west of the river, and the same was found in the Soules Bros. shaft on N. W., S. W. Sec. 21–12–8. In the Soules shaft a little limestone was found. A portion of what the Burke Bros. called hardpan may have been boulder clay, but there was a large mass of the conglomerate, as their dump pile fully proves. If the conglomerate takes the place of limestone, as on S. E. quarter Sec. 18–13–9, then in these shafts the limestone and sandstone are represented but not the fine clay shale. The sandstone and shale occur in the hills about Grant, in Nevins Township, and perhaps in other localities.

Coal "N" was called coal "N" east of the river and coal "L" west of the river by Prof. E. T. Cox in his report of 1870. The coal and attendant strata have been cut out by the river for a distance of about five miles, and it is a matter of considerable difficulty to correlate strata across such a wide gap. Coal "N" is known as the "Sugar Creek Coal." It outcrops at about high water mark at the base of the bluff west of Macksville, and has been mined in strip bank and shaft at many places on sections 6, 7, 8, 18 and 19, township 12 N., range 9 W., and on sections 13, 24 and 25, township 12 N., range 10 W. On the sections mentioned the coal is substantially horizontal from north to south, dipping slightly toward the west. From this region it dips to the north so that it is in the bed of the river at Durkey's Ferry. Then, judging from strata above, it runs nearly horizontal again till near the county line, when it rises rapidly toward the north and is found high in the hills three miles north of the county. South of sections 19 and 25 coal "N" dips to the south with the other strata, and does not come to the surface again in our county west of the river.

East of the river coal "N" has been mined in several localities. Commencing on the south it is mined on the S. W quarter section 32 of Pierson Township and on section 5, just south, in Sullivan county. The section of B. W. Forbes' shaft on S. W. section 32 is as follows:

Soil and subsoil clay	5 ft. + or —
Sandstone, mostly compact	40 ft.
Shale, with lime nodules	0 ft. 6 in.
Coal "N"	4 ft. 6 in.
Fire clay and shale	7 ft. + or —

The section at the Sharp Bros.' shaft, about a quarter of a mile south, is as follows:

Soil and subsoil clay	3 ft. + or —
Sandstone, massive	26 ft.
Shale—fine, light colored clay shale	14 ft.
Coal "N"	4 ft. 8 in.
Fire clay and shale	7 ft. + or —

The sandstone in each case is generally reddish brown and quite uniform in texture, but is easily crushed. It would make a beautiful building stone, but it is hardly firm enough for that purpose. An interesting fact shown by these sections is the total disappearance of fourteen feet of shale within a quarter of a mile.

Mr. Forbes tells me that while there is a little shale at the shaft in the mine, the sandstone generally lies upon the coal, forming the roof. The sandstone contains some coal fossils, and the shale next the coal is rich in fossil plants. This coal is found at Hartford, near the center of section 14, Linton Township, and along Russel's Run, on section 1, of the same township. Coal has been mined in this locality for many years. A section of Isaac Hipple's shaft on the N. E. ¼ S. W. ¼ section 1–10—9, is as follows: Soil, 3 feet; sandstone, 10 feet; shale, 17 feet; coal, 3 feet. The shaft being in a little valley, shows only a portion of the sandstone. The shale just above the coal abounds with fossils, and shows numerous examples of slickensides. In this mine the coal dips to the south about 1 foot in 20 feet, but is nearly horizontal east and west. But about 200 yards east of the mine, in the east bank of the run, the coal begins to dip rapidly toward the east, and is next found rising rapidly toward the north in the bed of the south branch of Honey Creek, on section 31, 11–8, about a mile and a half northwest and 50 feet below the coal in Hipple's mine. The coal on section 31 is about 2 feet, 6 inches in thickness, and has been mined in strip bank, but not extensively. The fossils in the shale and the slickensides in shale and coal are part of the evidence that the coal at Hipple's and on section 31 are the same, although for a long time I thought the balance of evidence was on the side of two distinct veins.

The shale overlying this coal outcrops in great cliffs along the south branch of Honey Creek for a distance of about four miles. On section 31 there are in it ironstone bands two to three inches in thickness and many ironstone nodules, but the bands thin out toward the north and south and finally disappear along with most of the nodules. North of section 31 this coal continues to rise for a short distance, then, changing direction, dips toward the north and does not appear again in form for economical mining till we reach the mines of the Burke Bros. and Soules Bros. on section 21 in Lost Creek Township.

Coal "N" occurs near Lockport in Riley Township; is some 30 feet below the bed of Stone Quarry Creek on Sec. 11–11–8, and is about the same distance below the bed of the creek on S. E. ¼ Sec. 26–12–8. It outcrops on the S. E. ¼, Sec. 14, and at different places on Sec. 12 of Lost Creek Township. Some of the earliest coal mining in Vigo County was from coal "N," on S. E. ¼, N. E. ¼, Sec. 16–12–8, by Alexander McPherson. In Lost Creek the shale that is so heavy over coal "N" in Linton, Pierson, Honey Creek and Riley townships has disappeared, and the sandstone in general lies on the coal, forming the roof. In a slope mine on Sec. 12 there is a layer of flattened clay stones, cemented together by reddish sandstone, just over the coal. The stones are seldom more than one inch thick or more than four inches broad. In the mines on Sec. 21 coal "N" is about five feet thick, but on sections 12 and 14 it is not more than three feet. In the mines on Sec. 21, where the vein is thickest, there is a thin dirt or slate band near the middle of the bed, which is not ordinarily found where the bed is thinner. Coal has been mined from this vein on Sec. 17–13–8 and at other places, but there is no extensive mining from this vein in Otter Creek or Nevins townships. The lower five or six feet of the shale above coal "N" on Sec. 17 is slaty in texture and highly bituminous. Coal "N" varies considerably in thickness and, possibly, in quality. On the east side of the river so much of it has been cut out by erosion that only comparatively small areas of coal occur, and exposure along the outcrops for centuries must have modified to some extent the character of the coal.

In the report of 1875 an analysis of coal from McPherson's mine, on Sec. 16–12–8, is as follows:

Fixed carbon	56.50	
Gas	37.00	
Water	2.50	
Ash, white	4.00	
		100.00
Coke	60.50	
Heat units	7,959.	
Specific gravity	1.239	
Weight of one cubic foot	77.43	

An analysis of coal "N" from Hartford shows:

Fixed carbon	49.00	
Gas	41.00	
Water	2.50	
Ash, white	7.50	
		100.00
Coke	56.50	
Heat units	7,721.	
Specific gravity	1.237	
Weight of one cubic foot	77.31	

West of the river the vein is usually thicker, but generally solid coal from the slate or bone coal above to the fire clay below. There is, perhaps, more pyrites in the vein on the west, but it is easily removed, so that as it comes to market the coal seems to be much the same in quality, whether from the east or west.

An analysis of coal "N" from a shaft near the railroad, on Sec. 7–12–9, is as follows:

Fixed carbon	47.50	
Gas	44.50	
Water	4.50	
Ash, white	3.50	
		100.00
Coke	51.00	
Heat units	7921.	
Specific gravity	1.210	
Weight of one cubic foot	75.62	

The fire clay, sandstone, shale and limestone between coals "N" and "M" are, in general, thin strata that do not require more than a passing notice.

Below coal "N" we find the following strata, as shown by the section of a shaft on N. E. quarter, S. E. quarter, section 17, township 11 north, range 8 west:

	Ft.	In.
Coal "N"	3	07
Fire clay	1	00
Sandstone, white	6	00
Shale, black bituminous	1	07
Limestone	6	00
Shale, bituminous, slaty	4 to 6	00
Coal "M"	5	04

The section in the Lochner Coal Company's shaft near Seeleyville is as follows:

	Ft.	In.
Coal "N"	3	00
Fire clay	2	00
Shale, light gray	16	00
Shale, dark colored	10	00
Limestone	0	08
Shale, dark colored, slaty	4	04
Coal "M"	0	02

Coal "M" is a good strong vein in Vermillion County and in Sullivan County, but is not a very important vein in Vigo County. It crops out in several places east of the river, but nowhere appears at the surface west of the river. Coal "M" is the upper vein at Clinton, where it is five feet thick. A section of the artesian well near St. Mary's shows: Coal "N" 5 feet, fire clay, white shale and soapstone 65 feet. Coal "M" 6 feet. A hole drilled by the Terre Haute Brick and Pipe Company showed "M" to be about the same distance below coal "N." No shaft has been sunk to this vein west of the river, so that we can know but little about it. Its character at Clinton and the section of the St. Mary's well lead us to expect a good strong vein underlying coal "N" west of the river.

East of the river we find coal "M" in the bank of Prairie Creek, on N. W. quarter, section 28–10–10, and on S. W. quarter, section 26–10–10 near Middletown. It also outcrops on the N. E., S. W., section 9–10–10, and at other places along the bluff, and also on S. E., S. W., section 10–10–10, about 30 feet above the outcrop on section 9. It occurs on S. W., section 23, at about the same level as on section 10. At neither of these places is the coal more than 18 inches in thickness, but in each locality it has been mined to some extent by stripping. It occurs on the N. W. quarter, section 30–10–9, with its attendant limestone and bituminous slaty shale. There are heavy banks of shale along a branch of Prairie Creek on S. half, section 17–10–9, which I can not locate with certainty, but think it is just below coal "N." The limestone in the bed of a branch of Prairie Creek, in sections 16 and 15, is probably the one above coal "M," which rises slowly toward the east. This rock disappears near the middle of section 15, and next appears in the bottom of the valley of South Honey Creek on the W. half, section 31, in Riley Township. From this place the rock with coal "M" rises to an outcrop on section 16, near Lockport. Coal "M" is mined on N. W., N. W., section 3–10–8, where the following strata are shown:

Soil and subsoil clay	18 feet.
Limestone, with numerous fossils	4 feet.
Shale, black bituminous, slaty	5 feet.
Coal "M"	3 feet.

In the shale above this coal there are many large limestone concretions or boulders. The coal found on the N. E. Sec. 33 and on E. ½ Sec. 36 of Pierson Township is, in my opinion, coal "M." But the coal on the E. ½ Sec. 24 may belong to coal "N." In general, coal "M" seems to be the surface vein throughout the southern tier of townships, coal "N" showing above it in two or three instances.

In the northern townships the vein is thinner than toward the south, so that the only locality east of the river where coal "M" is thick enough for successful mining, is near Lockport. On the N. W. ¼, S. W. ¼, Sec. 16–11–8, there is an outcrop of coal "M." The strata rise gradually toward the southeast, the outcrop showing along a little stream for a half mile or so in that direction, where they seem to run out. About 200 yards west of the outcrop, on N. E. ¼ Sec. 17, there is an old shaft in which coal "M" was reached at a depth of about 60 feet below the outcrop, and a drift was run from the shaft to the outcrop. From the shaft westerly the dip was more gradual. Toward the east the strata dip between 20 and 30 feet in a quarter of a mile, as shown by a drilling made while prospecting for a suitable place for a shaft. On the S. W. ¼. Sec. 9 there is evidence of a rapid rise of strata toward the east. We have here, then, a well-marked anticline, the western slope much more abrupt than the eastern. It probably extends southeasterly and then southerly as coal "M" on the N. W. ¼ of 3–10–8 is considerably higher than it is on the N. W. ¼, 6–10–8, showing a rise toward the east along the north part of Pierson Township. But the strata have been exposed at so few places that no very definite ideas can be formed as to their arrangement.

Coal "M," at the outcrop on Sec. 16, is about three feet. At the shaft it is five feet, and at the end of the west entry it is about six feet, showing a heavy body of coal in that direction.

West of the river, coal "M" is deep below the surface, but on Sec. 9–10–10 it is above high water, and on Sec. 10 it is higher still. But on Sec. 16–10–9, some five miles east, at a much lower level, the limestone above coal "M" rises slowly toward the east. When next seen it is deep in the valley of the south branch of Honey Creek, on Sec. 6 of Pierson Township. These facts seem to indicate that Johnson's Hill is part of an anticline and that the high lands near the northeast corner of Linton Township are part of another, and there is another near Lockport, so that a study of coal "M" shows, in the southern part of our county, at least three anticlines trending north and south. Coal "M" and its accompanying strata outcrop in several places north of Lockport, but I do not know of any place where it is mined at the present time. It is found in the south bank of Otter Creek, near Grant, on S. W. ¼, Sec. 27–13–8. In the report of 1875 it is stated that coal was mined in this locality by stripping, and an analysis of the coal was given, as follows:

Fixed carbon	44.00	
Gas	44.00	
Water	3.50	
Ash—red	8.50	
		100.00
Coke	52.50	
Heat units	7,592.00	
Specific gravity	1.216	
Weight of one cubic foot	76.00 lbs.	

The numerous outcrops of rock in the southern part of the county can generally be referred to strata attending coal "M." The limestone sometimes reached in wells about Prairieton is probably the limestone above coal "M," and, in general, outcropping limestone east of the river lies just above this coal. The sandstones and shales are probably between coal "N" and the limestone. The sandstones, sandy shales, etc., found along the old canal in the west part of Sec. 15 and on Sec. 22–11–8 are probably between coals "N" and "M." The black, slaty, bituminous shale that everywhere overlies coal "M" always contains numerous limestone balls, usually somewhat flattened and varying greatly in size, sometimes as much as two feet in diameter. The shale is generally fossiliferous, and in many cases there are delicate crystals of calcium sulphate or gypsum between the layers.

The big vein of Vigo County, the one from which most coal is taken, is coal "L." It nowhere appears at the surface west of the river and no shaft has been sunk to it in Vigo County, so that little is known about it. But the vein east of the river is quite well known, especially in the northern portion of the county. A few sections from different localities will help us to understand the relations of the various strata. A somewhat generalized section from the top of Sandford's Hill, Sec. 1–10–9, to Sec. 16–11–8, is as follows:

Soil and subsoil clay	10 feet.
Sandstone, with bands of shale	30 feet.
Shale, sometimes with ironstones	20 feet.
Coal "N," 1 foot to 6 feet	4 feet.
Fire clay and shale	3 feet.
Sandstone, variable	10 feet.
Shale, dark colored	2 feet.
Limestone, fossiliferous, hard (3 feet to 6 feet)	4 feet.
Shale, black, bituminous slaty (4 feet to 6 feet)	5 feet.
Coal "M" (1 foot to 6 feet)	4 feet.
Fire clay and shale—in drill hole	40 feet.
Sandstone—hard rock in drill hole	53 feet.
Coal and shale bands—"L" in drill hole	7 feet.
Total	192 feet.

The Lochner Coal Company's shaft on N. W. ¼ section 14–12–8, near Seeleyville, shows the following sections:

		Ft.	In.
1.	Soil and subsoil clays	13	00
2.	Hard pan, boulder clay	4	00
3.	Sandstone with black seams and fossils	22	00
4.	Coal "N"	3	00
5.	Fire clay	2	00
6.	Shale, light colored	16	00
7.	Shale, bituminous, slaty	10	00
8.	Limestone, some fossils	0	08
9.	Shale, black, some fossils	4	04
10.	Coal "M"	0	02
11.	Fire clay	3	00
12.	Sand rock, white silicious	44	00
13.	Coal "L," with slate band in center	6	00
14.	Fire clay and sandstone	4	00
	Total	132	02

The shaft of the Ray mine on the N. E. ¼ section 14–12–8, shows the following section:

	Ft.	In.
Soil and subsoil clays	14	00
Quick sand	7	00
Hard pan, boulder clay	34	00
Gravel	7	00
Sandstone, shaly	41	00
Slate, or sandy shale	1	00
Coal "L" upper portion	2	00
Clay or shale dirt band	0	02
Coal "L" middle portion	1	06
Clay or shale, dirt band and iron stone	0	04
Coal "L," lower portion	3	00
Fire clay and shale	6 + or —	
Total	107	00

The shaft of the Grant Coal Mining Company, just south of the center of section 27–13–8, in the valley of Otter Creek, shows the following section:

Soil, surface clay	3 feet.
Sandstone, sometimes shaly	20 feet.
Shale, light colored	4 feet.
Coal "L," 5 feet to 7 feet	6 feet.
Fire clay and shale	5 feet + or —
Total	38 feet.

There are several mines along the valley of Otter Creek, east of this shaft, which show about the same thickness of coal, with the clay shale and the sandstone above. At Fontanet, on section 13–13–8, the coal is near the surface in the valley of the creek. On section

tion 12, at the Union Shaft of the Coal Bluff Mining Company, the coal is about 100 feet deep. In this mine, in some cases, the roof is of boulder clay and sometimes rock, and sections on the same 40-acre tract vary widely, according to the thickness of the hard pan. A drill hole on section 12 shows as follows:

	Ft.	In.
Surface soil and sand	26	00
Shale, or soapstone	8	00
Shale, somewhat slaty	20	00
Coal, perhaps coal "M"	1	06
Fire clay	5	06
Sandstone	8	00
Shale, dark colored	9	00
Coal, "L"	6	06
Fire clay	1 +	or —
Total	85	06

Another on the same section shows:

	Ft.	In.
Surface soil and sand	37	00
Hard pan, boulder clay	74	00
Slate or shale, black	7	06
Coal and slate	2	00
Slate or shale, black	1	06
Fire clay and black slate	12	00
Total	134	06

In this case coal "L" and strata above had been cut out by erosion.

At Rosedale, in Parke County, about one mile north of the Vigo County line, and northward to Coxville, coal "L" has been mined extensively. Above it is the valuable glass sand of Coxville and vicinity.

At Lyford near the river, about three miles north of the county line, the section of a coal shaft is given as follows:

	Ft.	In.
Soil, surface sands and clay	10 +	or —
Coal, little vein	3	00
Fire clay and shale	5	00
Sandstone	12	00
Gray shale, some dark	35	00
Limestone, 8 inches; coal, 4 inches	1	00
Fire clay and shale	4	00
Sand rock	5	00
Shale, dark and light	12	00
Sandstone	12	00
Shale	5	00
Coal "L" with dirt band	6	06
Fire clay	2 +	or —
Total	112	06

At Clinton, Vermillion County, across the river from Lyford, the Buckeye Shaft, sunk by Dr. Samuel McClelland, shows the following below the upper vein supposed to be coal "M"?

	Ft.	In.
Shale, black, bituminous, slaty	3	00
Coal "M," outcropping	5	00
Fire clay and shale	3	00
Sandstone	20	00
Shale, light colored	20	00
Shale, sandy	13	00
Shale, slaty and brown with iron stones	6	00
Coal, little vein	1	00
Fire clay and sandy shale	8	00
Coal	1	08
Fire clay and shale	6	08
Coal	0	09
Shale, some sandy, varying in color	48	06
Coal	1	08
Fire clay and sandy shale	13	03
Coal, the lower vein "L"	5	10
Fire clay and sandy shale	3	06
Coal	1	10
Fire clay and sandy shale	8	00
Total	170	08

On William Morey's place, in Brouilett's Creek valley, just south of the county line, a drill hole which commences about 25 feet above low water in the Wabash, shows the following section:

	Ft.	In.
Surface soil, sand and gravel	4	00
Shale	50	00
Sand rock	1	08
Coal	3	06
Fire clay and sandy shale	12	00
Black rock and gray slate	5	00
Coal	4	09
Iron band and black slate	2	02
Coal	3	11
Fire clay	3	00
Limestone	9	06
Slate, gray	10	06
Sandy shale and sandstone	34	00
Iron band and gray slate	5	04
Coal	1	06
Shale and iron band	10	00
Sandy shale and iron band	12	04
Sandstone	14	00
Gray slate	2	00
Coal (probably coal "L")	6	06
Total	195	08

It is difficult to correlate this section with the one at Clinton, but I think it starts just below coal "M" and shows a thickening of the little veins shown in the Clinton section.

An artesian well drilled on the W. ½, S. W. ¼, sec. 6–12–9, shows the following section:

Soil and subsoil, yellow clay	20 feet.
Blue clay and quicksand	80 feet.
Shale, light colored	25 feet.
Coal "N"	5 feet.
Fire clay, white shale and soapstone	65 feet.
Coal "M"	6 feet.
Fire clay, white shale and soapstone	90 feet.
Coal "L"	10 feet.
Fire clay, white shale and soapstone	50 feet.
Sand rock, white	40 feet.
Total	391 feet.

Coal "L" and its accompanying strata outcrop at several places in the valleys of Nevins Township, but generally they are below the surface. The sandstone which occupies nearly all the space between coals "M" and "L" at Seeleyville varies somewhat in thickness and structure. In general, it is a coarse-grained siliceous sandstone, sometimes massive, sometimes shaly. It crumbles easily, even after it has been exposed to the air for some time, and would hardly be valuable as a building stone. At Coxville, in Parke County, where it forms cliffs along Raccoon Creek, it yields a valuable glass sand and is extensively quarried for this purpose. There are no outcrops in Vigo County as extensive as that at Coxville, but along the Otter creeks in Nevins Township there are ledges of stone that seem to be quite as good as that at Coxville. The rock at Seeleyville seems to be much the same as that at Coxville, except that it is uniformly white, while that at Coxville is streaked or mottled with red. The shale that generally lies between the sandstone and coal "L" is seldom very thick, and I found no extensive outcrop of it.

Coal "L" varies in thickness from five feet to ten feet, with a quite constant average of six feet. Its "trade mark," as J. Smith Talley calls it, is a shale or dirt band which divides the vein into two parts. The upper part is generally from three feet to three feet six inches in thickness, seldom varying much. The lower part is usually about three feet thick, but it varies widely; in fact, the variations in the thickness of coal "L" are usually confined to the lower part. Sometimes there is a thin iron band about 15 to 18 inches below the top of the upper part of the vein, but this is by no means constant. In some cases there are two clay bands, as shown in the section of coal on N. W., 30–13–7:

	Ft.	In.
Upper coal	3	06
Slate or dirt band	0	0½
Coal, middle	0	05
Slate or dirt band	0	0½
Coal, lower	2	06
Dead coal with sulphur	0	03

Coal "L" has been mined only in Lost Creek, Otter Creek and Nevins Townships. It not only exists in large quantities, but it is good coal, as good as either coals "N" or "M." An analysis of coal "L" taken from the old mine at Seeleyville is given in the report of 1875 as follows:

	Upper Part.		Lower Part.	
Fixed carbon	48.00		50.00	
Gas	45.00		43.50	
Water	3.50		3.00	
Ash, white	3.50		3.50	
		100.00		100.00
Coke	51.50		53.50	
Heat units	80.07		80.31	
Specific gravity	1.211		1.250	
Weight of one cubic foot	75.68		78.12	

An analysis of coal that represented the average output of "L" in the Ray mine at Seeleyville, made by Prof. W. A Noyes, is as follows:*

	Per Cent.
Total combustible matter	84.46
Volatile combustible matter	40.25
Fixed carbon	44.21
Moisture	7.57
Ash	7.97
Sulphur	4.01

The calculated heating effect per kilogram, in calories	6,656 calories.
Evaporative effect, per pound, of coal	12.4 lbs. water.

The report of 1875 says one pound of coal "L" will convert 12.31 pounds of water from 0°C into steam at 150° C. It is an excellent coal and possesses a high evaporative value.

The uniformity in thickness of coal "L" toward the north, and the fact that it is a strong vein in Sullivan County, with the evidence of its presence as a second or lower vein near Lockport, Riley Township, leads us to expect that it, as a good, strong vein, underlies the whole southern portion of our county.

Yet this is by no means certain. Near Middletown, on the N. W. ¼, Sec. 35-10-10, Mr. S. E. K. Fisk drilled a well to a depth of 441 feet. Commencing in a little valley, he reached coal "M" at a depth of 13 feet, then through 65 feet of shale or soapstone to one foot of coal, probably coal "L;" then through shale, sandstone and a little limestone about 100 feet to coal three feet and six inches thick, which is, perhaps, coal "K." Below this he found two or three thin veins of coal, and artesian water and gas at a depth of 430 feet.

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*See pages 98, 106 of this volume.

The strata of Vigo County rise toward the east. Coal "L" outcrops at Coal Bluff, and in Clay County, about three miles east of Seeleyville. Near the county line, in the bank of Otter Creek, on the east side of the N. E. ¼ of Sec. 8–13–7, two veins of coal are found. They are below coal "L," and the section is about as follows:

	Ft.	In.
Coal "L" as on Sec. 12–13–8	7	00
Fire clay and shale	25	00
Shale, black, slaty, sandy	2	00
Coal	2	06
Fire clay and shale	5	00
Shale, black, slaty	1	00
Coal	3	00
Fire clay and shale	10 + or —	

Mr. Talley says these two veins are about 25 feet apart at Perth, about three miles east in Clay County, and they are about the same distance apart at Fontanet. Some coal has been taken from these veins at the outcrop, but in our county they are too thin for successful mining as far as they have been explored.

A generalized section of four holes drilled near Caseyville, Clay County, show other veins of coal that may be looked for in Vigo County:

	Ft.	In.		Ft.	In.
Surface soil and clay	00	00		10	00
Hardpan—boulder clay	00	00		30	00
Shale and slate	00	00		10	00
Coal	2	6	to	4	5
Fire clay and shale	00	00		30	00
Coal	3	3	to	5	3
Fire clay and shale	00	00		30	00
Coal	00	00		3	7

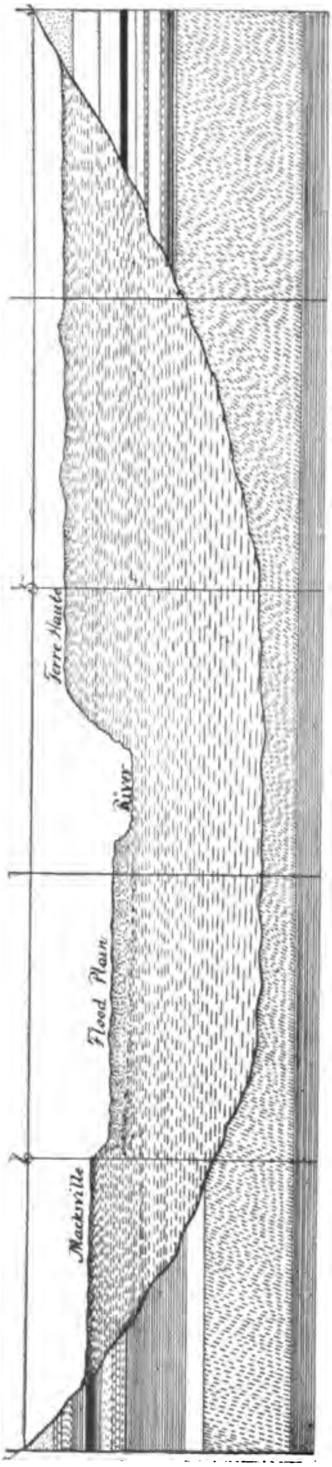
These are block or semi-block coals, and are mined extensively in the southeastern part of Parke County and the northwestern part of Clay County. Before reaching Vigo County these veins have become bituminous coals and are so thin bedded that it is not considered profitable to work them.

The numerous holes drilled for water, oil and gas have shown no other veins of coal or other rock strata that are liable to become valuable to the miner or quarryman.

TOPOGRAPHY.

Vigo County is a portion of a double slope. Its rocky strata incline westward toward the Mississippi and southward toward the Ohio, the westward slope being the more rapid. This circumstance seems to have had much to do in determining the topography of the county. The river flowing toward the south crosses the more rapid slope nearly at right angles. This dip of the strata westward probably causes the river to crowd its western bank, making it more abrupt than the eastern. The tributary streams flow easterly and westerly, with a trend toward the south, this trend being more pronounced in the western streams. The southerly dip of the rocks not only causes a southerly trend in the direction of the streams, but it causes them to crowd their southern banks, making them more abrupt than the northern. In general there are no streams flowing toward the north, the south branch of Honey Creek being the only stream of any size flowing in that direction. The greater portion of the surface of the county slopes toward the river, but portions of Riley and Pierson Townships are in the valley of Eel River. The divide between the two rivers is a massive body of land lying in Linton and the western part of Pierson Townships, and trending northeasterly through Riley Township. The northeast quarter of section 18, 670 feet, and section 20, 660 feet, of Pierson Township are the highest points in the county. Section 1 of Linton Township, and section 6 of Pierson, and portions of Riley have an elevation of from 640 to 650 feet, which is about the same as the higher portions of Fayette, Nevins and Lost Creek Townships While the strata in general dip to the west, there are some local exceptions or irregularities. In section 1, Linton Township, there is a sharp dip to the east, and another in Riley Township, with some evidences of another in Pierson, but the evidence is not sufficient to determine whether the divide is an anticline, or not. This divide is a rocky mass with just a thin veneering of boulder clay and soil, and must have divided these valleys in preglacial times.

The most marked feature in the topography of the county is the immediate valley of the river. It is from five to six miles wide and extends through the whole length of the county, but as the river forms the western boundary of the southern third of the county, only that portion of the valley on the east of the river belongs to Vigo County. This valley is an old channel that has been partly filled with sand and gravel. The numerous wells drilled in Terre Haute and vicinity shows the rock bed of this old channel to be from 120 to 150 feet below the general level of Terre Haute. The high land just east of the river, in the north part of the county, was part of an island in the ancient river. The channel east of the island is now occupied by Raccoon Creek of Parke County. This eastern channel



A Cross Section of the Wabash Valley at Terre Haute, Ind.

of the old river accounts for the sudden widening of the valley just south of the county line. In Prairie Creek Township there is another island. The narrow channel east of the island is now occupied by Prairie Creek. The valley of the river turns abruptly toward the west above the island and is somewhat narrow below. The main channel of the old stream was along the west bank. The rocky banks, the islands, the main channel, the secondary channels and shallow places are so well defined that we can almost see the old river, whose waters carved out such a broad, deep trough through our county. The river and its flood plain occupies the western one-third of the valley. The river washes the western bluff at Durkey's Ferry and its flood waters wash them at various places. The greater portion of the flood plain is from 14 to 18 feet above low water in the river, and scattered over them there are many ponds and sluggish streams, indicating a very uneven surface. Between the flood plain and the bluffs there are fragments of a low terrace, which is sometimes of gravel and sometimes of rock. The eastern two-thirds of the valley is occupied by a massive gravel terrace which has a somewhat irregular surface. Through Otter Creek Township it is much higher along the river, sometimes rising to 70 or 80 feet above low water, then sloping gently eastward. In Harrison Township it is not more than 50 feet above low water, and while there are low ridges and shallow valleys trending toward the south there is no slope toward the east. Through Honey Creek and Prairieton Townships the terrace gradually diminishes in elevation until it finally fades into the flood plain of Prairie Creek Township. Large portions of this terrace are flat and not well drained, so that they were originally swamps, marshes, wet prairies and ponds. The island that projects into the northern part of the county may, perhaps, be called a portion of the river valley. Where crossed by the county line the elevation is about the same as that of the high lands west of the river, but it soon begins to descend toward the south and within two miles has merged imperceptibly into the terrace. The surface is somewhat broken along the upper portions of Clear Creek.

The terrace is continuous into the valley of Raccoon Creek, and the ancient Raccoon Creek doubtless flowed into Vigo County, but while small portions of Nevins Township are drained into this creek, it hardly seems necessary to describe its valley.

Otter Creek, rising by several branches, generally in Clay County, drains a large and interesting area of country, including the greater part of Nevins Township and the southern portion of Otter Creek Township. The two main branches unite near the western boundary of Nevins Town ship. The valleys of these streams are from one-eighth to one-fourth of a mile wide, the stream usually nearer the southern bluff, which is generally more abrupt and more frequently rocky. The southern tier of sections in Nevins Township is drained by a third branch, which enters the main stream in the southeast part of Otter Creek Township. The branches of these streams are not large, nor numerous, but the land along the streams is badly broken up. On the divide between the north branch and Raccoon Creek valley there are several sections of good farm land, and some between the two branches, but fully one half of the township is too much broken for first-class farm-land.

The extreme southeastern portion of Otter Creek Township is very broken; the heavy bluffs south of the creek extending westward into section 31. North of the creek there are some hills, but no regular bluff. There is also some broken land in sections 5, 6 and 7, but in general the surface of this township is well adapted to agricultural purposes.

Lost Creek is a small stream that drains the central portion of Lost Creek Township, flowing through Harrison Township into the river. The valley is shallow, and the banks are seldom abrupt. Some of the smaller branches of the Otter creeks are evidently young streams, but the main creeks seem to flow in old channels. The valley of Lost Creek seems to be of recent origin. The extreme northeastern portion of Lost Creek Township is drained by a branch of Otter Creek, and a few sections in the southeast are drained by branches of Honey Creek, while a portion of the southwest is drained by Church's Run. Sections 1, 2, 11, 12, 34 and 35 contain about all the broken land of this township. Some sections, as 22, 23, 27 and 28 are nearly level, seeming to have about the same surface that was left by the glacier, as the drainage channels have not penetrated them to any extent. Harrison Township lies almost wholly in the valley of the river and generally has a good surface. Honey Creek, rising in Clay County, flows southwesterly through the southeastern sections of Lost Creek Township, through the northwestern portion of Riley Township, westward through Honey Creek Township, and southwesterly through Prairieton into the river. It is about the size of Otter Creek, but has a much longer course in the county than any other creek. It drains the southeast of Lost Creek, the north and west of Riley, the northwest portion of Pierson and the northeast of Linton townships and the whole of Honey Creek and Prairieton townships. In its southwesterly course to section 10 in Riley township the valley is somewhat symmetrical, but in its westward course the south bank is much more abrupt and extensive as it continues into section 21 of Honey Creek Township, while the north bluff stops in section 13 and is not strong there. It has several branches from the east and southeast, but the largest is the south branch, which drains parts of Pierson and Linton townships, being the north side of the highest elevation in the county. The valleys of this branch and its tributaries are deep, but somewhat irregular, perhaps more bluffy on the west, but not much difference. The southeast portion of Riley Township lies in the valley of Eel River, and is drained by Splunge Creek. The surface of this township along Honey Creek is much broken, but the greater portion of the township has a good surface.

A few sections of Honey Creek Township lying south of the main stream and along the south branch are broken, but by far the greater portion of the township has a good surface. The southeastern portion, about one-third, is upland; the balance is in the river valley. Some of the valley land is low and flat and has been drained with considerable difficulty.

Prairieton is wholly in the main valley. Along the river there is considerable flood-plain, and several bayous, but in general the surface is good, although some parts are marshy or swampy.

Prairie Creek rises by three branches in the north half of Linton Township. These branches unite in Sec. 8 of Linton Township, forming Prairie Creek. The creek flows westerly, and in the W. ½ of Sec. 7 enters the east branch of the old valley, and in Sec. 12 of Prairie Creek Township turns southwesterly to the S. W., N. W. Sec. 26, thence westerly to the center of Sec. 30; thence southerly into the river in Sec. 13-9-11 in Sullivan County. A branch rising in Sec. 21, Linton Township, flows into the main stream in Sec. 24 of Prairie Creek, and it receives quite a large branch from the north in Sec. 27. The branches seem to occupy recent valleys. They are comparatively shallow, and the bed of the stream is often rocky or of boulder clay. The branch of the old channel occupied by the main stream is about three-quarters of a mile wide, with some high bluffs and some low, sandy hills. Prairie Creek and its branches drain the greater part of Prairie Creek Township. Parts of Secs. 9 and 10 drain into Greenfield Bayou, and parts of Secs. 35 and 36 are drained southward by branches of Thurman's Creek. Nearly one-half of the township lies in the main valley and is mainly flood-plain. The valley of Prairie Creek, or the old channel east of the island, occupies about four sections, so that more than one-half of the township is bottom land. There is some broken land along the bluff lines, but it would not amount to more than three or four sections. The northern part of Linton Township is drained by the branches of Prairie Creek, while the southern part is drained southward by the branches of Thurman's Creek. Section 1 and parts of 2 and 12 are drained by the south branch of Honey Creek, while section 36 and parts of 25 and 35 are drained toward the south by a branch of Busseron's Creek. Portions of sections 6, 7 and 18 are in the old channel, but the greater part of the township is high land. The valleys of the streams are comparatively narrow and shallow, and there is very little broken land.

The northwestern portion of *Pierson's Township* is drained into Honey Creek, the eastern portion into Eel River through Splunge Creek and branches, and the southern portion is drained by the branches of Busseron's Creek. Sections 32 and 33 and parts of Secs. 6, 28, 34 and 35 are considerably broken. The balance of the township has a good surface and is well adapted for agricultural purposes.

Fayette Township is mainly drained by Coal Creek. A few little streams flow into Brouilett's Creek and the river, and a few sections are drained by East Little Sugar Creek. Coal Creek rises in Illinois and the west part of the township and flows southeasterly into the river. Its channel is deep, narrow and rocky, and its bluffs are abrupt. It seems to be a new or recent valley. The same is true of its branches and of two or three small streams that flow directly into the river.

Four or five sections in the northeast of Fayette are in the main valley, but the balance is upland. There are several sections of broken land along Coal Creek and the river bluffs, but the greater part has a good surface. This surface in the west is diversified with gently rounded hills of various sizes that rise from 20 to 40 feet above the surrounding level. Frank Leveret, of the United States Geological Survey, says they are parts of the Shelbyville or Wisconsin Moraine. Both north and south of Coal Creek the surface inclines gently from the State line to the bluff near the river, forming one of the finest slopes in the county.

Sugar Creek is the largest of the townships, and topographically is perhaps the most interesting. Big Sugar Creek runs from west to east across the center of the township. It is a strong stream, having a course of 20 or 25 miles in Illinois before entering the county. In Vigo County the valley is from 70 to 100 feet deep, and from one-half to three-quarters of a mile wide. The creek in general is near the south bank, which is much more abrupt than the one on the north. In Section 23–12–10 the creek cuts through the limestones above coal "N." At this point the rock channel is not more than 30 rods wide, while the valley proper is as wide as ever. In N. E. ¼, Sec. 25, where it joins the main valley, the rocky walls of this valley are not more than 40 rods apart. Above Section 23 the walls of the channel in this county are mainly of boulder clay. Sugar Creek receives only two or three small streams from the south, but has two large branches from the north. West Little Sugar Creek, which, rising in Illinois, enters at the northwest corner of the township, and, flowing a little east of south, joins the main stream in the east part of Section 22–12–10. And East Little Sugar Creek, which rises in Fayette Township near Coal Creek, and, flowing southerly, enters the big creek in the west half of Section 30–12–9. A branch of this creek rises in Section 34, Fayette Township, and, flowing a little east of south, enters the east branch in Sec. 24–12–10, so that the northern portion of the township is drained by three nearly parallel streams, each of which has a deep, narrow valley. Each of these streams shows some rocks in its banks or bed, but in general their channels are in boulder clay. The narrow channels of the main stream and of the east branch in their lower course suggests the idea that these streams may flow in recent or post glacial channels in the lower part of the course. The rocky strata dips toward the west but the surface inclines toward the east, and the thick beds of boulder clay toward the west may have changed the drainage area somewhat, so that a much larger territory is tributary to the present Wabash than to the ancient stream. Clear Creek, rising in Illinois, enters the county in the south part of Sec. 28–12–10, and flowing southeasterly joins the river in Sec. 11–11–10. Its valley is as deep as that of Sugar Creek but not as wide. Its channel is also rocky and narrow in its lower course. The extreme southern portion of the township is drained by two streams that rise in Secs. 3 and 4–11–10, and running in nearly parallel courses, flow into Hawk Creek which, flowing through Sec. 16, reaches the river near the center of Sec. 22–11–10. The surface of the township is very much broken, more so than that of any other township. The long river bluff, and the bluffs of two streams that cross the township, and the bluffs along the three streams that drain the northern portion, occupy fully 75 per cent. of the area of the township. The rocks associated with coal "N" crop out along the river bluffs and to some extent in other places, but in general the bluffs are of boulder clay, and one comes to think of the township as a mass of boulder clay and other glacial debris, through which the surplus waters are digging channels, as day by day they work at their task of carrying these materials down to the gulf. This task is only well begun. Wide areas on the divides are practically level, with no established drainage lines, showing little evidence of change since the retreat of the ice. The tributary streams, with their deep, narrow, V-shaped channels are reaching up into these areas and rapidly curtailing their extent. One can find numerous instances of from 6 to 10 of these little streams heading up into one 20-acre tract. Similar features occur to some extent in Fayette Township, and east of the river also, but in no place are they as well marked as in Sugar Creek Township. These peculiar forms of relief give the region a new and unfinished appearance. The broken nature of the surface is well indicated by the direction of the roads of the township.

The topography of Vigo County presents no very striking characteristics, but shows many very interesting features. The post glacial drainage system is young and has not yet been able to reveal the ancient topography in detail. East of the river the drainage in general follows the dip of the strata and the old drainage lines, so that the recent topography is probably quite like the old. On the west of the river, however, there is evidence of different lines of drainage, and other evidence which indicates a wide divergence between recent and ancient topographies.

ANCIENT CHANNELS.

The only records we have of this region during the nine or ten millions of years that intervened between the Carbonic and Quaternary eras are the old, half-buried channels that occupy so much of the area of our county. The main channel is somewhat irregular in width, but will average fully six miles from bluff to bluft. Like modern streams this old river had islands. Between Atherton on the west and Rosedale on the east a ridge of land rises some 200 feet above the river. It is the southern prolongation of a great island that divided the ancient stream, about three-fourths flowing on the west and one fourth on the east. The island is about 13 miles long and from two to four miles wide. Raccoon Creek now flows northward through the eastern channel of the old river. The island extends about two miles into Vigo County, descending rapidly but not abruptly from the county line toward the south. On the county line the western channel is about three miles wide, three miles north it is only two and a half miles wide, but soon spreads out to a width of three or three and a half miles. The east channel will average about one-half mile in width. From the southern point of the island, near the center of Sec. 7, to the eastern bluff in Sec. 16, Otter Creek Township, the distance is about two miles, which represents the channel of Big Raccoon Creek, Little Raccoon Creek and the east channel of the river. These combined with the main channel of the river and that of Brouilett's Creek make a valley six miles in width. In Honey Creek Township, where Honey Creek enters the main valley, the eastern bluff turns abruptly toward the west for about two miles to the center of Sec. 21–11–9, then southwesterly. In Prairie Creek Township there is another old island, known as Johnson's Hill. It is somewhat quadrangular in form, being about three miles in extent from north to south and from east to west. In sections 10, 9 and 16–10–10 on the northwest and in sections 13, 24 and 26–10–10 on the southeast, the bluff is abrupt, rising from 75 to 100 feet above the flood plain, while in sections 11, 12 and 21 the slope is very gradual down to the bottom lands. The eastern portion of the channel is now occupied by Prairie Creek, which in the west half of section 26 turns toward the west into the main channel in the east half of Sec. 29–10–10. On the south line of the county from the center of Sec. 32–10–10 to the western bluff in Illinois the distance is about five miles. The western bluff is more abrupt, more uniform in elevation and direction than the eastern, which in many places is low, the bed rock rising very gradually to the surface. The valleys of Otter Creek and its branches and of Honey Creek and its branches seem in general to be old, partly buried channels. But in the case of Lost Creek and Prairie Creek in its upper course the evidence is not conclusive.

I am inclined to think, however, that a portion, at least, of Prairie Creek valley is in an old channel. The old channel of Brouilett's Creek does not include much of Vigo County. Coal Creek valley seems to be recent—the work of the present stream. Sugar Creek and its branches are undoubtedly flowing in old channels, and so are Clear Creek, Hawk Creek and Big Creek from the west. It is sometimes suggested that the old channel of the Wabash was possibly the outlet of either Lake Michigan or Lake Erie, and that it is the result of a much larger drainage area than that of the present river. This question can scarcely be settled from a study of local details, but the size of the tributary valleys, which are supposed to be local, seems sufficient to warrant the idea that in general the ancient Wabash had a drainage area of about the same size as that of the present stream. During the glacial period water from Lake Erie flowed through the Wabash to the sea, and perhaps at other times also; but usually it probably had a more restricted drainage basin. The main channel seems to have been fully re-opened after the glacier, but there is evidence that many of the tributary valleys are still filled with boulder clay, gravel and sand, showing that the local drainage must have been much more extensive than would appear from a surface examination. In many cases along Otter Creek, Sugar Creek and other streams there are great bluffs of boulder clay upon which these streams are working in their attempts to clean out and occupy their ancient channels. The flow of water from Lake Erie, and perhaps other sources, enabled the river to clear out its old channel more rapidly than the local streams with only an ordinary supply of water.

In coal mines abundant evidence is found of much more extensive erosion than appears upon the surface. The Union mine, at Fontanet, is about 110 feet deep, through hard pan 55 feet, and rock 55 feet. But within 150 yards of the shaft the rock has been cut away and the boulder clay rests on the coal; while a few yards farther, in the same direction, the coal has disappeared, the rock and coal both being cut out by erosion and afterward replaced by sand, gravel and boulder clay. It is a common thing for the miner along Otter Creek or Raccoon Creek and in other localities to find the coal that is less than 125 feet below the plateau surface cut out by sand bars, gravel beds or boulder clay. So common and extensive are these old channels, that Mr. Talley, of the Coal Bluff Mining Company, tells me they never buy 40 acres of coal land without drilling at least four prospect holes in order to make sure they are buying coal and not simply boulder clay. Near Fontanet one drill hole penetrated boulder clay 120 feet. At St. Mary's it is 100 feet to bed rock and at Sandford it is about 150 feet. A little beyond it is 180 feet to shale, while the rock comes near the surface within a short distance of each of these localities. The south part of the county would probably yield similar testimony if it were tested with a drill. These facts indicate extensive local erosion prior to the Glacial period, and I think indicate that the proportion between the main river and its local tributaries was formerly much the same as at present. These channels vary in depth. The river wells reach bed rock about 80 feet below low water in the river or about 365 feet above tide, while the plateau in many places is over 600 feet above tide. Wells in other parts of Terre Haute reached shale at about the same distance below the river, so that we are sure that a considerable portion of the main valley was formerly 225 feet or more below the general surface of the uplands. The tributary channels are probably much shallower than the main valley, but little is known of them beside an occasional well. Drift materials are known to be of considerable thickness in the valleys of Sugar Creek and of Otter Creek. The beds of the present streams are from 60 to 80 feet below the general surface of the uplands, and the bed of the old channel is at least as much as 60 to 80 feet lower still. The walls of these old channels, where exposed, are often quite abrupt, so that the county in all the myriads of years had not been base-leveled. It is evident that a vast amount of material has been removed from Vigo County by erosion, but when we consider the length of time, the amount does not seem to be relatively great, and is seems probable that for much of the time this region was near the level of the sea, so that the action of eroding agents was weak and ineffectual.

THE GLACIER IN VIGO COUNTY.

In common with the northern parts of Ohio, Indiana and Illinois, Vigo County was once or twice covered with glacial ice. The causes of the glacial period are not known. It is generally believed that toward the close of the Tertiary era there was a very considerable elevation of the northern portion of the American continent. One result of this elevation was doubtless an increased rain-fall with much more vigorous erosion. It is probable that these extensive elevations were important factors in causing the severe climate that gave rise to the glaciers. The growth of an ice sheet or glacier, like most geological processes, is a matter of time. There were several gathering grounds, but the highlands of Labrador seem to have been the center from which the ice that covered the greater part of Indiana originated. On these highlands the snow and ice of the winter was not entirely melted by the heat of the following summer, and as this occurred year after year, and century after century, the ice gradually spread out over Canada, New York, Michigan and the greater part of Ohio, Indiana, Illinois and other States. During the centuries preceding the ice invasion, rain, heat and cold, vegetation, animal life, the chemical action of air and water had softened and broken up great quantities of surface rocks into materials from which soils, clays, sands, gravel and boulders were formed. As the ice advanced it gathered up these materials, broke up the more prominent rocky masses, ground down the hills, smoothed out the valleys and eroded the general surface more or less deeply.

The ice not only swept away the soils, but drove out or destroyed all forms of life and deluged the adjacent regions with summer floods. The regions passed over by the ice were smoothed and polished, and all the prominent features of the surface were softened down, and the whole aspect of the county changed. At length, for some unexplained reason, the ice ceased to advance and soon began to retreat. Its retreat was as gradual as its advance had been, each accompanied with halts and re-advances, but finally it was melted away and the glacier was no more. As the ice melted, the load of rocky fragments which it had brought from the Laurentian highlands, with additions gathered on the way, were left as a thick mantle of till or boulder clay spread out over all the region occupied by the ice.

This material filled up the old drainage channels, so that the surface was a plain of gently undulating surface.

But the floods from the retreating ice soon began to form drainage channels, sometimes reopening old channels, sometimes forming new ones, sometimes following old channels in general, but occasionally cutting off some bend, giving rise to many curious features in the streams of glaciated areas. The retreating ice for a long time made a dam across the Maumee Valley, so that a lake was formed. The surplus waters of this Maumee lake were discharged across the divide near Fort Wayne into the Wabash Valley and through it to the gulf. This extra supply of water seems to have cleared the old valley of boulder clay, at least in this region. The thickness of the boulder clay in Vigo County is from nothing up to 150 feet The thicker beds are probably in old channels. Frank Leverett, who has given the matter much attention, says that the average thickness for this portion of Indiana is about twenty-five feet. While the new drainage channels were being opened the surface of the boulder clay weathered into soil, and became covered with vegetation. The remains of this vegetation, partially decayed, mingled with the clay, forming a black soil. Similar soils are formed at the present time on poorly drained tracts in the northern latitudes. This old soil occurs in the eastern and southern parts of the county, under several feet of material deposited at a later period.*

Above this old soil there is a deposit of loess. "Loess is a fine-grained yellowish silt or loam, which overspreads the southern portion of the glacial drift in North America. It consists principally of quartz grains, but it usually contains a variety of such other minerals as occur in the drift. It is apparently derived from the drift, either by the action of water or of the wind. It often contains calcareous matter which partially cements it. Sometimes irregular nodules of lime and of iron and manganese oxide are found in this material. It also often contains fossil shells of land and fresh water mollusks, and occasionally remains of insects and bones of mammals. It has a strong tendency to vertical cleavage and usually presents nearly perpendicular banks on the borders of streams which erode it." It occurs at several places along the bluffs east of the river, and probably west of the river as well, but I have not noticed it there. There is a thick deposit in the bluff on the Bloomington road; in the bluff just south of Otter Creek and in the bluff at Atherton on the north line of the county. Over this loess there is, in southern Indiana, a continuous layer of pale silt called "white clay" which is the surface soil over much of the uplands of Vigo County.

Later a second ice sheet overspread the country reaching as far south as the northwestern part of our county, including Sandford. When the ice sheet halts for some time accumulations of gravels, sands and clays are formed by the materials dropped by the melting ice. Such accumulations are called moraines. Sometimes a continuous ridge of considerable extent occurs, but more generally the moraine consists of low rounded hills. The hills east and northeast of Sandford are parts of the Shelbyville or Wisconsin Moraine that marks the southern boundary or limit of a second ice sheet. The moraine extends northeasterly across the river into Parke

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*See Inland Educator for August, 1896.

County, being well marked to the north of Atherton. In the northwestern part of Fayette Township the white clay has been covered by a deposit of darker material brought down and deposited by this later ice.

The surface rocks of Vigo County are generally shales or friable sandstones which do not retain the marks of glaciation for any great length of time, so that but few glaciated surfaces have been found in the county. On the east side of the S. W. quarter, section 3–10–9, Linton Township, in the bank of a branch of Prairie Creek I found a glaciated sandstone, under forty feet of soil and boulder clay, the striæ running south, 25° west. Between the boulder clay and the rock there was a thin layer of very fine clayey material. On the N. W. quarter of the S. E. quarter, section 26–10–9 in the bank of a branch of Thurman's Creek I found glacial striæ on limestone and a glaciated fragment of similar rock in the boulder clay some twenty feet above the bed rock. The direction of the striæ was a little east of south.

The surface of the rock in the Lochner Coal Company's shaft at Seeleyville was glaciated.

At several places in bluffs of boulder clay I have found old wood from twenty to forty-five feet below the surface. Sometimes this old wood was fragile, soon crumbling on exposure to the air, in other cases it was in good condition and is still firm after being exposed to the air for a year. Wood has been found in digging wells in different parts of the county, so that old wood is quite common in the boulder clay of Vigo county. The specimens found were of cone bearing trees, probably some kind of cedar. One specimen showed over thirty rings of growth in a quarter of an inch. One ring was composed of only two layers or rows of ducts. These narrow rings of growth seem to indicate that there had been more winter than summer in the life of that little tree or shrub.

THE RECENT VALLEYS.

The glacier accounts, in a general way, for the soils and drift materials of the uplands, but the soils and other materials in the valleys need explanation. The old channel of the river was swept of boulder clay, probably by water from outside its ordinary water shed. After a time the ice melted out of the Maumee Valley, and the waters of Maumee Lake found a new outlet. The Wabash, diminishing in power, began silting up its bed with sand and gravel. This process continued until, in Vigo County, there was deposited a bed of gravel 20 miles long and four to five miles wide, and over 100 feet thick. This bed is of unknown extent toward the north and south. The great masses of gravel at Lafayette, and at intervening points, are, perhaps, parts of the same great bed. How can it be accounted for? In the record of some of the deep wells, the upper portion of the drift materials is shown to be coarse, while the lower is of smaller size. This, if a fact, suggests delta formation. One who studies the gravel pit will feel sure that the sands, gravels and boulders were arranged by water, but under what circumstances could the water get these rocky fragments of varying sizes together. A study of the upper portions, as seen in the gravel pits, suggests stream action, and possibly the whole mass was a delta formation whose upper portions were rearranged by stream action. Of something over 600 gravel stones examined, about 35 per cent. were limestones; the remainder were fragments of different kinds of granite rocks. The fragments vary in size from fine sand up to stones six inches in diameter, with occasional large boulders. The surface features, at least, seem the work of a strong stream. The ridge just west of Seventeenth street, which extends southward east of the old canal, seems to be an old sandbar. The ridge along Fifth street, which terminates in Strawberry Hill, is apparently another old sandbar. This mass of sand and gravel in the main stream must have dammed up some of the tributary streams, forming long, narrow lakes.

Later, the river seems to have become narrower and more rapid, possibly on account of elevation of the northern portions of the continent, so that the western one-third of the valley was cut down some 20 feet or more, leaving the eastern two-thirds as a gravel terrace. The margin of the terrace has a direct course a little west of south from three miles north of the county line in Sec. 13–14–9 to Sec. 5–11–9, Honey Creek Township, where it turns to the southwest.

Sometime after this the energy of the river seems to have been concentrated upon narrower limits and a channel was cut deeper into the gravel, leaving a narrow fringe of second terrace or second bottom along the western bluff, which is about 30 feet above low water in the present river, while the main terrace rises from 40 to 70 feet above the low water. Then the river ceased to erode the gravel, and even when in flood it can only work over the materials of its own floodplain. As one watches the river when in flood, with its deep, strong current and finds it unable to erode the gravel he can not help wondering as to what manner of a stream it was that cut out that great mass of gravel and carried it to unknown distances below. The river flows along or near the western bluffs, and its tributary streams flow along the southern bluffs. This is universal. There is hardly a rocky cliff or bank of boulder clay that does not face toward the north or toward the east. I can think of only two or three exceptions along the narrow parts of Coal Creek Valley. This is perhaps due to the fact that the strata generally dip toward the south and west. It is possible that the main current of the stream that deposited the gravel was on the west and that the gravel was not as deep on the west. If true, the later streams had less work to do than we have ascribed to them. The lands of Vigo County were surveyed in

1815 and 1816. The meander of the river made at that time was not carefully done and the records are incomplete, so that no very definite conclusions can be reached as to the amount of change made in the course of the river since that time. But it seems certain that in no instance since that date has the river been able to erode the gravel. Those portions of its channel, where at least a fringe of timber has been left along the river have not materially changed. But on the curves, where the timber has been cut away, the erosion has been extensive, so that the bed of the river has moved from 600 to 800 feet, as at the bends in S. E. Sec. 8, and S. W. Sec. 16–12–9, and in S. W. Sec. 32–12–9, Harrison Township.

The main terrace descends gradually towards the south from the north part of Honey Creek Township to the northern part of Prairie Creek Township, where it becomes the flood plain. Whether the terrace formerly extended farther south and has been cut down by erosion to its present extent and form, or whether it never extended any farther than at present, and has the original termination modified only by ordinary atmospherie influences, are questions which I can not solve. I am inclined to the opinion that the high terrace never extended much beyond its present position.

Just above Clinton, Vermillion County, about five miles north of our county line on the west side of the river, a section of the high terrace terminates quite abruptly. It rises about 60 feet above low water, while the second terrace on which Clinton stands rises from 35 to 40 feet above the same level. The river valley is narrow, only about two miles wide in this locality. The high terrace appears again about two miles below, but on the east side of the river and in full force just below the narrow place in the valley. The high terrace does not seem to have been formed in the narrow portion of the channel. Many streams flowing into the main valley are lost in the sands and gravels. In time some of them brought down clay enough from the hills to puddle large areas of sand making it impervious to water, and marshes, swamps and wet prairies were formed. Fort Harrison prairie, which extended through nearly the whole length of the county was largely wet prairie that had its origin in obstructed drainage. The Macksville terrace across from Terre Haute is a typical gravel terrace, but much of the second bottoms is really a rocky shelf. Near the I. & St. L. R. R., it is a shelf of shale above coal "N." South of Sugar Creek, for some distance, it is a shelf of limestone. Other interesting features of the old valley might have been mentioned, but enough has been said to show that the channel of the Ancient Wabash contains many interesting problems for the one who has time and opportunity for studying them.

The tributary valleys differ widely from the main valley. In them the drainage was purely local, and it, at times, was not relatively as strong as in the main valley. The great floods from the retreating glacier soon ceased to influence the local streams, but continued for centuries to strengthen the river. Changes of level that would materially affect the character of the main stream might have little effect on the tributary. The boulder clay was all removed from the main channel in a comparatively short time, while the tributaries are still, after thousands of years, working on the boulder clay with which the glaciers long ago filled their channels.

In general, the tributaries seem to have cut downward as rapidly as the river, but could not open their channels to the full width as did the river. When the river silted up its channel with sands and gravel, they filled theirs mainly with sand, the local streams not being able to move as coarse material as the river. In some instances, at least, the main stream filled its channel so rapidly as to shut off the tributary stream, making it a pond or lake. In one of the branch valleys of Sugar Creek, on the N. W. ¼, S. E. ¼, Section 22–12–10, there is a deposit of very fine laminated clay, with occasional partings of fine sand, the whole resting in a trough of boulder clay. Where this deposit outcrops on the main creek it is from 12 to 15 feet in thickness, becoming thinner as it extends back from the creek. In some places it has the appearance of shale, but to the touch it is fine clay. I found some similar material about a quarter of a mile down the creek, which seems to indicate that the deposit was formerly more extensive, but had been carried away by erosion. I once saw an extensive deposit of similar material in Sullivan County, northeast of Merom.

The deposit is an interesting one, and indicates that this valley was occupied by quiet water for centuries, and that then the barriers were removed, the lake flowed away and the obstructed drainage system was reopened. The valley of Sugar Creek, in Secs. 16, 22 and 23, is wider than below, and the same thing seems to be true of East Little Sugar Creek, in Secs. 12 and 13. None of the other valleys have a similar form. The flood plain of the tributary streams is of different material from that of the main stream. It is more local in its character—sometimes clayey and impervious, again sandy or loamy. In many cases the smaller streams carry away valuable materials from their flood plains, while in general the river leaves its flood plain covered with a coating of rich, fertilizing sediments.

THE SOILS OF VIGO COUNTY.

Soils, for the most part, are fragments of rocks, and contain in varying proportions the same chemical elements which enter into the composition of the different rocks. The destiny of the rock masses which make up the continents, is the bed of the sea. The rocks softened by water, expanding by day, contracting by night, fractured by the frosts of winter, by the roots of growing vegetation and other agencies, are finally broken down and carried away toward the sea by running water, by ice or by the wind. As these fragments move along, now rapidly, now slowly, sometimes resting by the way, they are gradually abraded and worn down as they jostle each other, till they become rounded boulders, gravel stones, sand grains and clay. Portions of these sands and clays, during some of their resting stages form the soils that cover the rocks and support the varied forms of vegetation.

Our soils are mainly of glacial origin. The boulder clay which forms so much of the uplands of the county is made up of clays and sands and gravels and boulders of various kinds. The great majority of the larger fragments are of granitic rocks from the Laurentian highlands, but there are numerous fragments of limestone, and some of sandstone and coal. The sandstone, the coal and some of the limestone, seem to be of a local origin. The gravels, sands and clays of the tributary valleys are doubtless of local origin, derived from the boulder clay which forms so large a part of their channel walls. The soils and subsoils of the main valley are mainly from foreign sources, although of glacial origin. The river at Durkey's Ferry and in N. W. quarter Sec. 14–11–10, Sugar Creek Township, is eroding shales. Coal Creek, Sugar Creek, Otter Creek, Honey Creek, and others, are eroding native rocks in many places, so that native rocks contribute considerable material to the soils of Vigo County, but the per cent. is very small when compared with that furnished by the products of Glacial action.

During the later erosion of the valleys, the boulder clay of the uplands or divides under atmospheric influences, became weathered or oxidized into yellow clay, which for the most part is the subsoil of the uplands. Upon this early soil there seems to have been a vigorous growth of vegetation, the remains of which added to the clay formed a rich dark soil, remains of which occur at several points in our county as on the N. W. quarter Sec. 32–11–9, Honey Creek Township, on the S. E. quarter Sec. 25–12–8 and on the S. W. quarter Sec. 24–12–8 Lost Creek Township.

After this erosion, and these soil changes had gone on for centuries, the whole area seems to have been covered with a fine, white clay, which is close and compact, but not sticky like the yellow clay. This difference between the two clays is very manifest in the roads that have not been graveled. On the level areas, where the white clay has not been cut away, the road may be firm and solid, but as it descends a little slope and comes into the yellow clay it may become almost impassable on account of the deep, sticky, mud. This white clay is the surface soil over most of the uplands of Vigo County. It belongs to the "White Clays" of southern Ohio and Indiana, which are described by Frank Leveret, of the United States Geological Survey, as of glacial origin.[*] "A detailed study of the upper Mississippi region, by Professors T. C. Chamberlain and R. D. Salisbury led them to the conclusion that the distribution of the loess and associated silts and clays is best explained on a hypothesis of fluvio-lacustrine deposition. Evidence was found that the altitude of the region was much below the present, perhaps not far above the sea level, but instead of its being occupied by an inland sea, it is their conception that the valleys became silted up so that at the maximum of depression they were occupied by shallow, perhaps marshy, lake-like rivers many miles in width, whose waters moved slowly seaward from the edges of the ice-sheet. The constitution of these silts shows a direct derivation from glacial waters." The thickness of these clays is four or five feet along the border of the moraines, gradually thinning out toward the south, the thickness 20 to 30 miles from the moraine being little more than half as great. The thickness in Vigo County is from 8 to 24 inches. The largest continuous area of this white clay occurs in Lost Creek Township. From a bank at the roadside on S. W., S. W., Sec. 27–12–8, I took samples of the surface white clay and of the subsoil yellow clay. The white clay was from a depth of 10 inches, and the yellow clay from a depth of about 22 inches. These samples were analyzed by Prof. W. A. Noyes. The composition of the clays dried at 135°C is as follows:

	Yellow Clay.	White Clay.	Yellow Clay.	White Clay.
Silica (SiO_2)	72.87	79.77	51.40	79.94
Alumnia (Al_2O_3)	11.25	9.95	3.44	6.45
Ferric oxide (Fe_2O_3)	6.73	3.39	[†]2.42	[†]1.53
Potassium oxide (K_2O)	2.26	2.05		
Magnesium oxide (MgO)	1.06	0.26		
Calcium Oxide (CaO)	0.69	0.67		
Sodic Oxide (Na_2O)	0.39	1.08		
Titanium oxide (TiO_2)	0.95	0.70	......	......
Water (H_2O)	4.24	2.55	.....	......
Total	100.44	100.42	60.36	82.92

RATIONAL ANALYSIS.

	Yellow Clay.	White Clay.
Quartz	42.43	52.30
Feldspathic Detritus	17.93	30.62
Clay substance	39.64	17.08
Total	100.00	100.00

[†] Insoluble in acids and sodium carbonate.

On the slopes in many cases the white clay has been washed away, exposing the yellow sub-soil, so that a field looks spotted. But in such fields it is difficult to detect any difference in the appearance or yield of the crop growing on the two soils. Yet their difference, as shown by the analysis, is very well marked. In the northwestern part of the county, which is supposed to have been covered by the ice a second time, the white clay is covered up or mingled with other material, so that quite a different soil is the result. This mixed soil is called by some a better soil than the white clay. In the southeastern portion of the county, the Splunge Creek valley has a good soil which is neither a white or yellow clay, but seems to be a clayey mass like the sediment at the bottom of a pond or lake. It is free from gravel and boulders, and is not as sticky as the yellow clay. There are, perhaps, 12 or 15 square miles of this soil, most of which in the early times was covered with a rich mantle of prairie grasses. Sections 33 and 34, Prairie Creek Township, include some "quicksand land." The soil is a whitish clay for perhaps 8 to 15 inches, which is close and compact. Underneath this is the fine sand and clay which forms the quicksand. The upper soil will generally bear a team with an ordinary load when in motion, but if allowed to stop the load is liable to break through into the quicksand. In plowing, the horse on the unbroken soil has no difficulty, but the one that walks the furrow is frequently in the mire. The soil is fairly good, but is not considered as good as adjacent land in which there is less of the fine sand.

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[*] See the American Geologist for July, 1892.

Along the bluffs on the east side of the river there are deposits of loess which at some places form the surface soil, but not over any large areas. Between Otter Creek and the valley of Raccoon Creek there are large numbers of sand dune hills, and several sections of land have a light, sandy soil which seems to have been blown from an ancient beach by the prevailing westerly winds. In some cases the sand lies on the bed rock, but generally it overlies boulder clay. Similar areas, but of less extent, occur north of Honey Creek, as on Secs. 12 and 13 of Honey Creek Township; also along Prairie Creek, as on Secs. 21 and 25, in Prairie Creek Township. In the northwestern portion of Fayette Township there are many areas of black lands that are much like the prairie lands of Illinois, and possibly they may be outlying masses of the prairies. The Morainic Hills, east and north of Sandford, are sometimes sandy, and sometimes wash easily, so that they can not be profitably cultivated. Along the bluffs of the river and its principal tributaries there are many steep slopes over which the drainage is so rapid that the soluble portions of the soil are washed away, leaving an impoverished residue that produces but a scanty vegetation. Such areas are numerous in Nevins Township along Otter Creek, and they occur along Coal Creek and Sugar Creek.

The main valley of the Wabash is divided into flood plains and terraces. The flood plain has a deep soil of alluvial sands and clays, varying widely in character from pure sand to rich clay. But the sands, mingling with the finer silts, soon become fertile lands. The clays are open and porous, so that the water penetrates them freely. These soils are generally rich and easily tilled. On the bottoms there are many shallow ponds, or sloughs, over whose beds oftentimes a deep black soil accumulates. The terraces usually have a sandy soil. But large areas, being nearly level, become covered with silt, so as to be nearly impervious to water, forming marshes or wet prairies with deep, rich soils. There are many sections of such soil in Otter Creek, Harrison, Honey Creek and Prairieton Townships. The tributary valleys have a rich alluvial soil, but it is largely of local origin, and is not as fine, nor as open in texture, as the soils of the main valley. Of the soils mentioned the alluvial clays of the flood plains, the sands of the terraces, and the clays of the uplands constitute the great bulk of the soils of Vigo County; the others, while occupying considerable areas, make up but a small per cent. of the whole.

A specimen of the alluvial clay of the flood plain from a depth of about two feet was analyzed by Prof. W. A. Noyes with the following results:*

Silica	66.11	
Alumina	13.78	
Water (combined)	6.34	
Clay base and sand		86.23
Oxide of iron	5.35	
Lime	1.67	
Magnesia	1.78	
Potash	2.11	
Soda	1.51	
Fluxes		12.06
Total		98.29

The sample was of clay that is used by the Terre Haute Pressed Brick Company in the manufacture of a good grade of dry-pressed brick, and represents the purer clays of the flood plain. Nearer the river there is more sand, often so much that it can not be used for brick making. Sometimes the clay is seamed with sand, and again the sand and clay will be quite distinct, though near each other, but the fine sediments brought in, year by year, soon make them both, sand and clay alike, rich and productive soils. We have no analysis of the sandy soils of the terraces, but a simple acid test shows them to contain quantities of lime. The gravels, coarse and fine, which appear to have had much the same source as the soils, contain much lime, at least 35 per cent. of the stones are rounded fragments of lime rock. These soils are more easily worked than the upland clays, and are quite as productive, and will in general wear longer; that is, will produce more good crops in successive years than can be produced on the clays.

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* See 20th Geological Report, p. 76.

The dense forests of native trees and the prairies with their rank growth of vegetation, proclaimed the richness of the soil to the early settlers. And the great fields of corn and wheat, the market garden products, and other crops that have contributed so much toward the wealth of the county, testify to the value of the soil under cultivation.

ECONOMICAL GEOLOGY.

The soils of Vigo County are her most abundant source of revenue. They have been, are, and probably always will be, the basis of her material prosperity. The glacier scoured the country for 600 miles in gathering up the materials for our soils. These somewhat heterogenous materials, rearranged in various ways by wind and water, and enriched by centuries of vegetable mould, constitute the widely varying soils of Vigo County.

The dense forests of valuable timber, the river prairies with their rank growth of forage grasses and the rich, easily cultivated soils, were the chief attractions to the early settlers of this region.

The first export from Vigo County was perhaps a cargo of furs, but the first and most important one to the early settler was a cargo of corn. The corn was shipped in the spring on flat-boats, usually to New Orleans. These flat-boats were made, for the most part, of yellow poplar, sometimes called white wood or tulip tree. This timber grew abundantly in the north part of the county on both sides of the river, but perhaps the finest and largest were on the east. The building of flat-boats for the corn and pork trade made great inroads upon the stock of yellow poplar, so great that one frequently hears an old settler speak about how the flat-boat trade destroyed the yellow poplar. While doubtless this valuable timber was used in a wasteful way in those early days the supply was by no means exhausted, and many farmers of Vigo County, after these many years, still get some income from the sale of yellow poplar. The black walnut was perhaps the most valuable timber tree of the county. It grew abundantly on the bottom lands as well as on the uplands, but those growing on the bottoms were larger and had a larger proportion of dark or heart wood. The supply is mostly gone, but in its day it was one of the important sources of revenue to the county. There are several different kinds of oak in the forests of the county, but perhaps the most valuable is the white oak. It grows on the uplands and often in the creek bottoms, and is more abundant in the northern portions of the county, Fayette Township being conspicuous for the size and quality of its white oaks. White ash, hickory, beech, maple, cottonwood, elm and sycamore all grow well in Vigo County, and are marketable trees. There are many acres of land in Vigo that, on account of their broken and rugged character, could hardly be made good plow land that are well adapted to the growth of these valuable native trees. The black walnut, the yellow poplar, the linden or basswood, the white ash, the cottonwood, hickory and sycamore are all rapid growers, and would grow well on what is at the present time practically waste land. A growing crop of valuable timber trees is better than waste lands.

The crop of Vigo County is corn, and it grows best on the flood plains of the river and its principal tributaries. The wheat and hay crops are, perhaps, next in importance, while market-garden products from the lighter sandy soils are taking a leading place. The grasses of Vigo County have made her pasture lands famous among stock raisers, and it is claimed that the famous blue grass of Kentucky was imported from Indiana.

Coal.—The second most important natural product is coal. The county is rich in coal of a good quality. Two veins have been mined on the west side of the river and three on the east. On the west of the river there seem to be four veins of coal. Coal "O" outcrops along Coal Creek and at other places in Fayette Township. It is from three feet to five feet in thickness, and is good coal. In the eastern part of the township it lies considerably above the river and has been badly cut up by erosion, but there is still a large body of coal in this vein that can be mined easily and cheaply as soon as markets are opened and shipping facilities established.

Coal "N" outcrops along Sugar Creek and at points along the bluffs, west and northwest of Macksville. It is known as Sugar Creek coal. From the south part of Sec. 19–12–9, for over three miles northeasterly, the coal is nearly horizontal, being about the level of high water in the river. To the north and south of this region the coal descends, and but little is known of its thickness and character. As far as explored, it is a good strong vein from four feet to six feet in thickness, with a good shale roof. It has been cut out to some extent by erosion, but there is reason to think that "N" is a good workable vein, extending over the greater part of Sugar Creek and Fayette townships. Coal "M" does not outcrop in Vigo County west of the river, and has never been mined in that part of the county. But the artesian well at St. Marys shows "M" to be a five-foot vein, with a good roof, only 65 feet below coal "N." The well drilled for oil just west of Macksville showed this vein about 100 feet below the upper. It is a good vein at Clinton, and while coal "M" varies considerably on the east side of the river, we have reason to expect that "M" is a good workable vein over the greater portion of the county west of the river. Much that has been said of coal "M" can be said of coal "L," except that "L" is a thicker vein and, when explored, is generally more uniform than "M." The St. Marys well shows "N" at 125 feet below the surface as five feet, "M" as a six-foot vein 190 feet below the surface, and "L" as a ten-foot vein 280 feet deep, so that three workable veins of good coal, aggregating 21 feet in thickness, occur west of the river. The strata dip toward the west, so that the coals are rather deep in the western part of the county; but the quantity of coal in these three veins underlying Vigo County is enormous.

On the east side of the river three veins have been worked for coal. The upper vein, "N," is not generally a strong vein. It varies considerably in thickness, but is usually good coal, and has a good roof of sandstone or shale. While much of it has been cut away by erosion, there are still thousands of acres of workable coal in this vein on the east of the river.

The middle vein "M" varies widely, from six feet near Lockport to two inches near Seeleyville.

I think the Alum Cave mines, with their 7 to 9 feet of coal, are on coal "M," but it thins out rapidly in all directions. Near Lockport it dips rapidly toward the west and increases rapidly in thickness. Does this change continue or does it soon thin out? We hardly know what to expect of coal "M" east of the river, but it must surely contain a great body of coal. The workable coal in these veins is mostly south of the National Road.

The big vein east of the river is coal "L." North of the National Road it lies near the surface, and has been channeled by erosion so that fully one-half of its area is gone, and in many places where the coal is left the roof has been destroyed so that mining is difficult or impossible. It varies from 6 to 10 feet in thickness, and while the slate bands are to be substracted from this mass, there is still left a "big vein" of coal. It outcrops in many places in Nevins Township and has been mined extensively there. It is a strong vein from Seeleyville northward to Rosedale, Coxville, Lyford and Clinton. It has not been explored very fully south of the National Road, but several drill holes indicate that it is a strong vein in the southern part of the county as well as in the northern.

Below coal "L" come the block coal veins of Clay County, but they have diminished somewhat in thickness and in general have ceased to be block coal, so that it is not considered profitable to mine from them. Southeast of Seeleyville drillings show some block coal, but it has not been fully explored.

The data are not at hand for estimating with any degree of accuracy the quantity of good available coal in Vigo County. But with "N" four feet, "M" four feet, and "L" six feet, with "O" above and the block coal veins below the coal supply of the county seems well nigh inexhaustible.

Shale and Clay.—In the Twentieth Report on the Geology of Indiana the origin, composition, classification and uses of shales and clays were discussed somewhat in detail, so that it will not be necessary to consider those phases of the subject at this time.

The stratigraphical column of Vigo County is headed by a thick stratum of shale that outcrops in great cliffs along West Little Sugar Creek in sections 4, 9, 10 and 15 (township 12 north, range 10 west) and along Coal Creek in sections 14, 15 and 23 (township 13 north, range 10 west) in Fayette Township. In these localities this shale is fully 50 feet in thickness. The great body of this bed is a fine aluminous shale of a dark-blue color. On Sugar Creek, toward the surface, there is some admixture of silica, and on Coal Creek there are sandstones and sandy shales of considerable quantity, but by much the greater portion of the stratum is fine shale.

No analysis was made of this shale, and I have never seen brick made from it, but there is no doubt but that it will make building brick, paving brick, sewer pipe or tiling of the very best quality. Below this bed and above Coal "O" there is a bed of shale from 30 to 50 feet in thickness. Sometimes this shale is interstratified with limestone, so that the thickness of good shale is much reduced, but generally the limestone forms one compact stratum with a bed of very fine aluminous shale below it, as on Coal Creek, near the gravel road, on section 20, township 13 north, range 9 west, and similar outcrops occur on sections 6, 9 and 17, same town and range. This shale is of a lighter color than the upper, and seems to be freer from silica. Between Coals "O" and "N" there are three shales, one above the limestones, one between them, and one below. The upper shale on the southwest quarter of section 19–12–9, and on section 25, township 12 north, range 10 west, is above the limestones, while Thorpe's shale on southeast section 23–12–10 is between the limestones, and the shale of the Terre Haute Brick and Pipe Company on section 18–12–9 is below the limestones. Specimens of the upper shale from William Larimer's place on section 25 were made into bricks with a Boyd dry press machine, and some were burned for building brick, and some for pavers. They are excellent brick. The building brick are of a rich dark-brown color, uniform throughout, have a clear metallic ring, did not shrink much in burning, and did not warp, and they are tough, not chipping easily. Architect Floyd, of Terre Haute, said of them, "that no finer brick were ever laid in Terre Haute, and that they were worth $30.00 per thousand, as well as one dollar was worth another."

The paving bricks shrunk considerably in burning, but did not warp. They are hard and tough, and absorb but little moisture. One of these brick, tested for strength by Prof. Malverd A. Howe, at the Rose Polytechnic shops, gave the following results:

"A brick from Vigo County shale. Cross breaking test. Area of cross section 8.49 inches, supported on knife edges six inches apart; the force applied by knife edge midway between the supports, using the Riehle testing machine. The brick broke under a pressure of 6,040 pounds, showing a strength per square inch of 2,900 pounds. In the compression test the brick was on cast-iron supports, with pine bedding. Area, 6.27 inches. The specimen cracked at 88,000 pounds and failed at 95,500 pounds, showing a strength per square inch of 15,230 pounds. A brick made from the bottom land clay used by the Terre Haute Pressed Brick Company, when subjected to the same tests, showed a cross-breaking strength of 1,300 pounds per square inch, and a compression strength of 11,940 pounds per square inch. Another, composed of one-third shale from Sec. 25, and two-thirds bottom land clay, showed a cross-breaking strength of 1,700 pounds per square inch." The Terre Haute Brick and Pipe Company are making brick and tile from shale that lies immediately above Coal "N." Their bank is on the N. E. N. E Sec. 18–12–9. They make paving brick by the stiff mud process, some of which are re-pressed. These bricks are of excellent quality, as shown by the following tests made by Prof. M. A. Howe, for George H. Simpson, city engineer of Terre Haute, who attempted to select average (not the best) brick for the tests. The brick were supported on rounded knife edges six inches apart, and force applied through a knife edge acting midway between supports. One brick with a cross-section of 2.37x4 inches and another of 2 44x4 inches, when lying on the side, showed a cross-breaking strength of 2,630 and 2,240 pounds per square inch, respectively.

In another test, brick from the same factory had a breaking strength of 2,720, 2,780, 3,360, 1,820, 2,170, 2,310 and 3,530 pounds per square inch. A brick from the river clay, subjected to the same test, showed a cross-breaking strength of 1,440 pounds per square inch. Some common soft mud brick, from bottom-land clay in the south part of Terre Haute and burned hard, showed a cross-breaking strength of 570, 540, 890 and 920 pounds per square inch, and a compression strength of 1,410 and 2,010 pounds per square inch. A brick two thirds shale and one third bottom-land clay showed a cross-breaking strength of 1,200 and a compression strength of 5,070 pounds per square inch. Brick made by the T. H. B. and P. Company, subjected to the absorption test, showed, after forty-eight hours in the water, .7, .7 and .22 per cent. of absorption, while the brick from the alluvial clay showed 4.34 per cent., and a Veedersburg brick 1.08 per cent. These tests show that at least some of the shales of Vigo County make good brick of the very highest quality. The shale between the limestones is of excellent quality, but it probably is not as available as the shale above. This shale extends over a considerable area, but is of no great thickness. The 12-foot outcrop on Sec. 23–12–10 is the thickest I have seen. The great shale deposit of Vigo

County is the body of shale lying over coal "N" on both sides of the river. The cliff of fine shale at Durkey's Ferry, the shale bank of the Terre Haute Brick and Pipe Company, the cliff of shale along the south branch of Honey Creek, along Stone Quarry Creek and the fine shale near Lockport all belong to the same bed. The tests made of the Terre Haute Brick and Pipe Company's brick show that this shale west of the river is of good quality. The brick from this shale are not of as dark color as those made from the shale above the limestones.

On the N. W. ¼ of Sec. 6–10–8, Pierson Township, there is a fine cliff of this shale, known as the "Paint Mine." The shale is pulverized, barreled and shipped to different parts of the country to be used as a body for paints. The company has worked under difficulties of various kinds, but no fault has ever been found with the material it sends out. The industry seems destined to grow in importance as the value of the shale comes to be appreciated. In this locality there are several ironstone bands in this shale, with many nodules of the same material. One owner of the quarry used to make hone stones from these clay ironstone layers that were of the finest quality. They were known as the "Fera hone stones." The shale from this locality makes good brick, but they are light in color. If the ironstone were crushed with the shale, the mass would doubtless make a brick of good color and great strength. . There are several outcrops of this shale in Pierson, Riley and Honey Creek Townships, and some in Nevins Township. This shale is everywhere a fine aluminous shale, generally thick bedded and easy of access in scores of localities.

There is a cliff of fine shale on the S. W. ¼ Sec. 17–10–9, but I am not sure whether it is above or below coal "N." But on the north half of Sec. 13–11–9, Honey Creek Township, there is an outcrop of shale with overlying sandstone, which seems to lie above coal "N." Below it is a fine shale, which graduates upward into a fragile reddish sandstone. Specimens taken so as to represent the average of the bluff, both sand and shale, were sent to H. S. Grimes, Portsmouth, Ohio, who had them made into "Hall block" pavers. When he sent the brick to me, Mr. Grimes wrote "that there never was a better brick made." They were of a rich brown color and apparently in every way a first-class brick. They were considerably lighter than the ordinary block and somewhat lsrger, as they did not shrink in burning.

There are good shales at several points in Nevins Township, both above and below coal "L," but I have not been able to study them in detail.

The common mud brick used in Terre Haute are made mostly by hand from alluvial clays from the flood plains of the river. This material varies widely in composition, and never makes a really first-class brick although they may surpass many. Some portions of these alluvial deposits make excellent dry pressed building brick, but does not make a first-class paver, as the tests already made seem to show. Clays from which common building brick may be made abound everywhere on the uplands of the county. Some of the shale would certainly be valuable for the manufacture of at least the lower grades of pottery. A deposit of fine clay on Sec. 22–12–10 is said to be suitable for encaustic tiling and high grade pottery wares. A partial analysis of this clay by Prof. W. A. Noyes is as follows:

Silica	50.36	
Alumina	15.08	
Oxide of iron	4.45	
Loss by ignition	13.98	
		83.87
Undetermined substances		16.13
		100.00

Prof. Noyes says that the undetermined substances appear to consist largely of lime. The clay, he thinks, may be of value for earthenware and similar products.

Sandstone.—There is an abundance ot sandstone in the county, but little, if any, of it is good for building purposes. In the eastern portion of Fayette Township, along the bluffs, small quantities of very good sandstone may be found, but such masses are not extensive enough to make the quarrying of it profitable. Sandstone has been quarried at two or three places along Coal Creek and on a little creek in the S. W. corner of Sec. 28–13–9, and perhaps in other places along the bluffs. It has also been quarried at different places on the east side of the river, but merely for neighborhood use.

The sandstone above coal "L" is a coarse-grained, silicious sandstone that is sometimes a very handsome stone. At Coxville, Parke County, this stone pulverizes into a very valuable glass sand. Over coal "L" at Seeleyville there is over 40 feet of this sandstone that seems to be of exceptional purity. After the coal is taken out the sandstone can be stoped down and raised to the crusher quite as cheaply as if it were in a cliff.

Limestone.—There is a double limestone above coal "N," west of the river, and a limestone over coal "M," east of the river, and one over coal "O," in Fayette Township. The limestone above coal "O" is generally so disseminated through the shale that it does not form a quarry rock. But in the top of the hill on S. W., Sec. 20, it forms a ledge of fine, compact, clayey limestone about three and one-half feet in thickness. I could form no idea of its extent. Some limestone has been quarried from the bluffs in the eastern part of Fayette, but it was simply for local use. Some has been quarried from S. W. ¼ Sec. 19–12–9, but the most extensive quarry was on N. E., Sec. 15–11–10, in the south part of Sugar Creek Township, where rock was taken out for use in improving the river. On the east of the river considerable stone was quarried along Honey Creek near Lockport for use in improving the National Road, and occasionally for domestic purposes. I know of no limestone that has ever been burned for lime.

Iron Ores.—In the shales of the coal measures iron carbonate mixed with clay is often common. It is known as kidney iron ore or clay ironstone. This form of iron ore is abundant in the shales overlying coal "N." It occurs in nodular masses and in distinct layers or strata. When the Blast Furnace at Terre Haute was in operation hundreds of loads of this material were brought to the furnace every year. The stones were thrown out of the creek bed during the summer and hauled to the furnace during the fall and winter. While not productive of much revenue, these iron stones are worth preserving.

Other Minerals and Ores.—Governor William Henry Harrison, in a letter dated December 10, 1809, to the Secretary of War, regarding a treaty with the Kickapoo Indians, says: "I was extremely anxious that the cession should have extended to the Vermillion River. This small tract of about twenty miles square is one of the most beautiful that can be conceived, and is, moreover, believed to contain a very rich copper mine. The Indians were so extremely jealous of any search being made for this mine that the traders were always cautioned not to approach the hills that are supposed to contain this mine. I know there are individuals who have turned their attention toward this mine, and will probably prevail upon the Indians to show them the mine." He then urges that the Government take immediate steps to secure this tract of land. The tract mentioned included a portion of Vigo County west of the river.

This old tradition is still alive, and has grown somewhat. The mine now contains silver, as well as copper, and is talked of in secret and with bated breath, as if there was still danger attending upon the approach toward those hills. The copper consisted of specimens of native copper, brought by the glacier, of which many have been found in Vigo, Vermillion and Parke Counties. I have one weighing 19¾ pounds, found in Parke County, that has on it well defined glacial striæ. The silver is the whitest kind of iron pyrites, so common in the shales of the coal measures. No copper, silver, nor gold has ever been found in paying quantities in connection with coal formations, and we can not hope to find them in Vigo County.

Mineral Oil.—Oil seems to be abundant in the deep strata of Vigo County and, when found, is a source of considerable revenue. It seems probable that at no distant day a more extensive field may be opened, and the production of oil become one of the important industries of Vigo County.

Natural Gas.—The flow of natural gas was so strong from some of the artesian wells that many have thought that we are in the gas belt, but as yet it has not been found in paying quantities.

Sulphur Water.—The sulphur water, so abundant from the artesian wells, is a valuable medicinal agent. It is especially useful in rheumatic complaints, and many other ailments are benefited by the use of this water for bathing or drinking.

ARCHÆOLOGY.

The relics and remains of ancient pre-historic peoples are found in many parts of the earth. The river and its larger tributaries abounding with food fishes and mussels, the forests and prairies crowded with game birds and animals that were valuable for their flesh, skins or fur, and the rich, easily tilled soil of the readily accessible second bottoms made Vigo County and vicinity a favorite dwelling place for primitive man. When the French traders penetrated these regions they found Indian villages on the Terre Haute Terrace, and evidences that they had been occupied for uncounted centuries.

As the region was more carefully explored, the remains of an ancient, and apparently a different people, were found—a people whose historic records are limited to fragments of bones, bits of charcoal, broken pottery-ware and masses of kitchen refuse—to implements of bone, flint and stone, to desecrated shrines and violated tombs.

These people are known as the "Mound Builders," because of the great number of earth mounds which they built and used for various purposes. The most numerous are the burial mounds, and these are generally the smallest in size. In addition to the burial mounds there were temple or sacrificial mounds, and lookout or signal mounds. The burial mounds are usually artificial and so are the sacrificial mounds, but the signal mounds are often partly natural.

There are in Vigo County, perhaps, 300 mounds. In Otter Creek Township there is a group of mounds on the edge of the terrace in the S. W. ¼ of Sec. 14-13-9. The largest one of this group is about 10 feet high, 50 feet in diameter at the base, and about 20 feet in diameter on the summit. On this mound several oak trees were growing. A large one that had been cut down showed 203 rings of annual growth. The terrace at this place rises about 50 feet above the flood-plain, and at present is about one mile from the river. There are a few small mounds on the west bluff of Otter Creek in the N. E. ¼ Sec. 27 nearly 50 feet above the creek. There are a few mounds on the prairie near Fort Harrison, in the S. W. ¼ Sec. 3 and S. E. ¼ Sec. 4 of Harrison Township. There are mounds in the S. E., S. E. Sec. 32-12-9, on the N. E., S. E. and S. W. quarters Sec. 5-11-9, on S. fraction Sec. 6, and N. W. ¼ Sec. 7-

11–9, these forming a group of more than 100 mounds, extending for two miles along the edge of the terrace which rises from 30 to 40 feet above the flood-plain. The mounds of this group vary greatly in size, from 30 feet in diameter and an elevation of six feet, down to five feet in diameter and one foot in elevation. Many of this group have been obliterated by cultivation. There are a few mounds about nine miles south of this group on the N. E. ¼ Sec. 9, Tp. 10 N. R. 10 W., on ground that just rises above high water. Another group of interesting mounds is situated in the valley of Prairie Creek on the N. W. ¼, N. W. ¼ Sec. 28, and the S. ½ Sec. 21, and on the S. E. ¼, S. E. ¼ Sec. 20, Tp. 10 N., R. 10. W. Some of these are just above high water, while others are on the hillside at least 40 feet above the floods. In the S. E. corner of Sec. 29, Prairie Creek Township, there is a hill or mound about fifty feet high which seems to have been a point of the bluff that was topped out by the mound-builder and used as a signal mound. The summit has been used as a burial place, but probably by tribes of a later date than those who used the mound for signal purposes.

In Sullivan County, south of this mound, there are several large mounds, rising to an elevation of about 75 feet above the flood plain, and from 25 to 30 feet above the terrace. About one-half mile back from the edge of the terrace, on the N. E. ¼ Sec. 8·9·10, there is one that has an elevation of about 40 feet, a length from east to west of about 400 feet, and from north to south of about 300 feet. It is, perhaps, the largest and most symmetrical mound in the State. These large mounds were, perhaps, burial mounds, but they have never been explored. Two on the edge of the terrace, on Secs. 6 and 7, might have been signal mounds. But why so near each other? Why little mounds for 20 miles through Vigo County, and then a few large mounds without little ones? On the top of the one on Sec. 6 there is a secondary mound in which was a stone grave containing several skeletons. These may have been the remains of later tribes.

On the west side of the river there are mounds on Sec. 34–15–9, six miles north of the county line, and some on Brouilett's Creek, in some of which were stone graves. But the only ones in Vigo County are a small group on the second bottoms near Macksville. Just south of Darwin, across from the big mounds of Sullivan County, there is a large group of rather small but symmetrical mounds. Bones from these mounds are badly decayed. It is seldom that a bone is found in a good state of preservation, while bones from the stone graves at Merom, in Sullivan County, are often well preserved.

If these 300 mounds represent all the burials, then the Mound Builders made but a short stay in this vicinity and occupied but a small portion of its area. If they represent the burials of the priest and ruling families only, still their stay must have been comparatively brief. Bones of men, women and children have been found in these mounds, indicating that they were family burial places. If these mounds do not represent all the burials, how were the remains of other families disposed of? Possibly they were buried, but the evidence of this is not very clear.

The large group along the terrace in Secs. 32, 5, 6 and 7, mainly in Honey Creek Township, are nearer the river than any of the others, and this location may possibly indicate that the river flowed along the terrace when the mounds were built, as it does now, and that they were built at a comparatively recent date. The location of some of the mounds along Prairie Creek, and of the mounds below Darwin, seem to point toward the same conclusion.

On the N. E. ¼, N. E. ¼ Sec. 29–10–10, there are the remains of an ancient pottery. The fragments of pottery scattered through the soil, over a considerable area, indicate that it was quite an extensive affair.

Many of the smaller mounds have been opened, that is a hole has been dug in the center of the summit. Very frequently portions of skeletons have been found, but none in a good state of preservation. One skull, taken from a mound on Sec. 21–10–10, had the marks of an idiot's skull, so that unfortunates or imbeciles are not the exclusive product of civilization. Besides the bones of the Mound Builder and the mounds that were built over them, some evidences of his skill, industry, habits, enterprise, etc., have been found. Among them are stone axes, stone celts or hatchets, flint implements, as arrow points, spear heads and rimmers, ornaments of copper, mica, galena, hematite, of shells and bones, pipes of stone and slate, and catlinite, a discoidal stone of symmetrical form, made from a quartzite pebble, etc. These implements and ornaments indicate considerable skill and intelligence, industry and energy, and that the makers were possessed of no mean artistic ability. The copper, galena, mica, slate and hematite indicate extensive commercial relations. The pipes tell the story of raising tobacco, of crude agriculture and dreamy contemplation.

The remains of the Mound Builder found in Vigo County perhaps add nothing to our knowledge of these ancient people, but they confirm in many respects the conclusions arrived at from the study of relics found in other localities. Who were the Mound Builders? Where did they come from, and what became of them? It does not seem possible for us to find out the history of these people. The following seems a probable account of them. These people came from the western plains into the forests and prairies of the Ohio Valley. They had made considerable advance in culture, lived in communities under settled forms of government and religion. Agriculture and commerce were important industries. The custom of building mounds was unique; it seems to have been developed in the Ohio Valley, and never was practiced to any extent elsewhere. The rich soils of the river valleys yielded an abundant return for their labor, but the rank growth of native vegetation made agriculture a more arduous industry than in the drier regions of their ancestral home. With crude and inefficient tools, and without domestic animals, it was difficult to defend the growing crops from the vigorous natural vegetation. There was an abundance of game and fish, wild fruits, berries and edible roots growing everywhere. Surrounded by such a wealth of natural products, more and more of the people became fishermen and hunters. Agriculture was neglected, the towns were deserted, forms of culture were dropped, till finally they sank to the level of surrounding tribes, and, broken up by cruel, savage warfare, were gradually destroyed or absorbed by neighboring people. Primitive man has seldom practiced agriculture successfully in a forest region. Whatever may be their history, we must ever feel a lively sympathy for this people, who, outstripping their contemporaries, came very near making a permanent advancement; then, overcome by their environment, gradually dropped out of the race and sank into oblivion.

THANKS.

In the preparation of this report I am much indebted to the writings and personal advice of Frank Leveret, of the United States Geological Survey; of Frank B. Taylor, of Fort Wayne, and of Prof. C. R. Dryer, of Terre Haute. I am also indebted to J. Smith Talley, S. M. Reynolds, Martin Deill, Thos. and John Broadhurst, Dr. S. McCleland, Duncan McCullum, and to many others, who have kindly aided me in every way possible.

A CATALOGUE

OF THE

UNCULTIVATED

FERNS AND FERN ALLIES (PTERIDOPHYTA)

AND THE

FLOWERING PLANTS (SPERMATOPHYTA)

OF

VIGO COUNTY, INDIANA.

BY W. S. BLATCHLEY.

"How ineffably vast and how hopelessly infinite is the study of nature! If a mere dilettante observer like myself—a saunterer who gathers posies and chronicles butterflies by the wayside for the pure love of them—were to tell even all that he has noticed in passing of the manners and habits of a single weed—of its friends and its enemies, its bidden guests and its dreaded foes, its attractions and its defenses, its little life history and the wider life history of its race—he would fill a whole book up with what he knows about that one little neglected flower; and yet he would have found out after all but a small fraction of all that could be known about it, if all were ever knowable."—*Grant Allen.*

INTRODUCTION.

Many catalogues of the flowering plants of different localities in this and other States have appeared in recent years, each varying much in the nature of the information contained. Some were mere lists of scientific names. Others contained much valuable information regarding the variations, and habitat of the plants recorded. All added more or less to the known geographical distribution of plants.

My reasons for preparing and publishing the present list are several:

First.—The botany of any region is closely related to the geology thereof, and no better place could probably be found for the printing of a catalogue of the flora of Vigo County than immediately succeeding the foregoing report and map of the geology of that county prepared by Dr. Scovell.

Second.—During a seven years' residence of the county a large number of notes relating to the variation, distribution, and comparative abundance of the flowering plants were collected. As no flora of the county has ever been published, and as the State Normal School is located at Terre Haute, it was thought that a list, with such notes added, might be of aid to future students of botany in that institution.

Third.—Many indigenous plants once common in western Indiana are becoming rare or have already disappeared. They could not withstand our modern civilization. In the words of Thoreau: "The Indian stood much nearer to wild nature than we. The noblest quadrupeds, the largest fresh water fish, some of the wildest and noblest birds and the fairest flowers have receded as we advanced, and we have but the most distant knowledge of them."

From the primitive fauna of Vigo County have disappeared the buffalo, bear, wolf, panther, elk, deer, wild turkey, ivory-billed woodpecker, paroquet, wild pigeon, rattlesnake and copperhead, together with the noble red man, the one time contemporary and lord of them all. From its flora will soon be stricken the yellow lady's slipper and showy orchis, the wild orange red and turk's cap lilies, the yellow puccoon and blue cohosh, the ginseng and squill, the nelumbo and white water lily, the black walnut and yellow poplar, all of which were once abundant; while already many flowers which once decked with their brilliant and varied colors all the prairies on either side of the Wabash River, have wholly disappeared, and, in their stead, we find those coarse, unsightly weeds of civilization—aliens from a foreign shore—which have ever accompanied the white man on his westward march. The native plants, now rare, will soon have wholly disappeared from the flora of the county. That a permanent record of that flora, as it now exists, may be accessible to future generations, is the principle reason for the preparation of the present list.

TOPOGRAPHY AND SOILS OF VIGO COUNTY.

River Bottoms.

The number and variety of the flowering plants of any region are determined very largely by the nature of the topography and the character of the soils, as well as by the latitude, mean annual temperature, etc. The topography of Vigo County is a varied one. The Wabash River flows through its northwestern corner, and in many places its bottoms, which are usually overflowed each season, are two to four miles wide. Embraced within the area of these alluvial bottom lands are numerous sloughs and ponds, some of them covering an area of 40 to 80 acres, whose waters are replenished by each annual overflow. Within the waters or about the muddy or sandy margins of these ponds grow many plants rarely found in other portions of the State or not hitherto recorded from within its bounds. Some of the more notable of these are the Upright Bur-head, *Echinodorus cordifolius* (L); Swamp Horsetail, *Equisetum fluviatile* L.; Water Milfoil, *Myriophyllum verticillatum* L ; Pondweed, *Potamogeton spirillus* Tuckerm.; Catchfly Grass, *Homalocenchrus lenticularis* (Michx.); Columbia Wolffia, *Wolffia columbiana* Karst.; Sandwort, *Arenaria serpyllifolia* L., and Downy Poplar, *Populus heterophylla* L.

River Terraces or Prairies.

Bordering these lowland bottoms on the east side of the river are level river terraces, or prairies varying in width from three to eight miles. In some places, as near the Five-Mile Pond, north of Terre Haute, these terraces rise higher and more abruptly than elsewhere, and the soil both on the slope and on the level above is very sandy. In such localities certain plants are found which have been recorded elsewhere in the State only from the sand dunes along its northern border. Among such may be mentioned the Diffuse Panicum, *Panicum autumnale* Bosc.; Hair-like Stenophyllus, *Stenophyllus capillaris* (L.); Carolina Whitlow Grass, *Draba caroliniana* Walt.; Frostweed, *Helianthemum canadense* (L); Whorled Milkweed, *Asclepias verticillata* L., and Houghton's Synthris, *Wulfenia houghtoniana* (Benth.).

The surface of most of the level river terrace has long since been cultivated, but in the vicinity of Heckland, nine miles north of Terre

Haute, are several small tracts of virgin prairie as yet untouched by the plow. The soil of some of these is low and wet; of others, high, dry and sandy. This region, when carefully examined, proves to be a veritable botanist's paradise. Here has been found a large percentage of the plants worthy of especial mention in this report. Of these, the Canadian Burnet, *Sanguisorba canadensis* L.; the Goldenrods, *Solidago speciosa* Nutt., *S. rigidiuscula* (T. & G.), and *S. odora* Ait.; the Greenish Orchis, *Habenaria flava* (L); the Larger Yellow Lady's Slipper, *Cypripedium hirsutum* Mill.; the Rose Mallow, *Hibiscus lasiocarpus* Cav.; the Lance-leaved Violet, *Viola lanceolata* L., and the Soapwort Gentian, *Gentiana saponaria* L., are the most notable. This locality furnishes, also, the only stations in the county where representatives of that typical prairie flora, once so prominent in the western third of our State, can yet be found; and here, in their respective seasons, the Bluets, *Houstonia cœrulea* L.; Scarlet Painted Cups, *Castilleja coccinea* L.; Blazing Stars, *Lacinaria scariosa* Willd., and *L. pycnostachya* Michx.; False Indigo, *Baptisia leucantha*, T. & G., and Queen of the Prairie, *Spiræa lobata* Gronov., flourish in beauty and profusion.

Uplands.

On the east side of the river terraces are the uplands, usually more or less broken or hilly, which extend to the eastern confines of the county and are underlaid with coal. The ravines and hillsides in the vicinity of Grant—Ferrell's woods in section 6, Riley Township, and Hipple's Coal-mine woods in section 1, Linton Township — are localities of the eastern uplands of especial interest, each with a number of characteristic species not noted elsewhere in the county.

On the western side of the river the uplands approach the river bottoms closely, a narrow terrace only intervening. Here also coal underlies the surface, and in many places along the smaller streams high, dry, wooded hills are found. The most interesting of these, botanically, are along the south side of Coal Creek in sections 19 and 24, Fayette Township. Here is the home of such noteworthy species as the Five-flowered Gentian, *Gentiana quinquefolia* L.; the Virginia Obolaria, *Obolaria virginica* L.; the Bracted Orchis, *Habenaria bracteata* (Willd.); the Rattlesnake Plantain, *Peramium pubescens* (Willd.), and the Canada Waterleaf, *Hydrophyllum canadense* L , besides many others noted in the list

Along the sandy banks of the old Wabash and Erie canal, and the gravelly banks of the railways, especially the Vandalia, between Terre Haute and Glen,* many a rare species grows and blossoms, unnoticed save by the insects, which visit it for nectar, and the wandering naturalist, ever on the lookout for the interesting and the beautiful among the common and the dross. Many of the plants along the canal are without doubt the descendants of species introduced two score years and more ago when busy commerce reigned supreme up and down this artificial road of water.

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*By a mistake, the station of Glen was wrongly located on Dr. Scovell's map of Vigo County. It should be at the crossing of the Vandalia Railroad and National Road, near the center of Section 16, Lost Creek Township.

Thus we note that the extensive river bottoms, the sandy ridges, the prairies damp and dry, the ponds and sloughs, and the uplands with their ravines and wooded hills furnish a variety of topography and soils suitable to the existence and growth of many kinds of plants. Indeed, it may be said that every character of topography occurring in Indiana is represented in Vigo County, with but one exception, namely, the rocky hills characteristic of Brown and eastern Monroe counties, and other portions of southern Indiana. On account of the absence of such hills a number of plants, whose general range includes the entire State, do not occur in the county. Among the more notable of these are many species of the family *Ericaceæ*, as limited in Gray's Manual, which is represented only by two parasitic species belonging to the genus *Monotropa*. Others are the Indian Cucumber Root, *Medeola virginiana* L.; the Common Dittany, *Cunila mariana* L ; the Fragrant Sumach, *Rhus aromatica* Ait.; the Choke Cherry, *Prunus virginiana* L., and the Small Honeysuckle, *Lonicera dioica* L., besides a number of species of ferns.

PLANTS OF SOUTHERN RANGE.

One interesting characteristic of the flora of Vigo County is the presence of a large number of plants whose true range lies much farther south. Their occurrence as far north as central Indiana can only be accounted for by the broad and sheltering valley of the Wabash, within the confines of which they find a climate and a soil congenial to their wants. The following list comprises twenty-five of the most notable of these southern forms:

Pitcher's Clematis, *Clematis pitcheri* T. & G.
Pond Cress, *Nasturtium sessiliflorum* Nutt.
Densely-flowered St. John's Wort, *Hypericum densiflorum* Pursh.
Rose Mallow, *Hibiscus lasiocarpus* Cav.
——— ———, *Psoralea melilotoides* Michx.
Sedum, *Sedum telephioides* Michx.
Sweet Gum, *Liquidambar styraciflua* L.
Ammannia, *Ammannia coccinea* Rottb.
Sinuate-leaved Primrose, *Oenothera sinuata* L.
Northern Passion Flower, *Passiflora lutea* L.
Purplish Cudweed, *Gnaphalium purpureum* L.
——— ———, *Hymenopappus scabæosæus* L'Her.
Butterweed, *Senecio lobatus* Pers.
Persimmon, *Diospyros virginiana* L.

Obtuse-leaved Milkweed, *Asclepias obtusifolia* Michx.
Climbing Milkweed, *Enslenia albida* Nutt.
Trumpet Creeper, *Tecoma radicans* Juss.
Blue Curls, *Trichostema dichotomum* L.
Large-flowered Mint, *Synandra grandiflora* Nutt.
——— ———, *Phyllanthus carolinensis* Walt.
Pecan-nut, *Carya olivæformis* Nutt.
Downy Poplar, *Populus heterophylla* L.
Glaucous-leaved Green-brier, *Smilax glauca* Walt.
Upright Bur-head, *Echinodorus rostratus* Engelm.
Kyllingia, *Kyllingia pumila* Michx.

Many others might be mentioned whose range for the most part lies far to the southward, but the above are sufficient to show that in Vigo County is found a northern extension of true southern forms, a locality where a northern and a southern flora overlap and merge.

DATE OF FLOWERING OF EARLY SPRING PLANTS.

The following is a record of the dates of flowering of seventy species of plants in Vigo County during the months of February, March and April for the years 1889, 1890, and 1891. The dates given are those upon which the first flowers of each species were noted by the writer in the years mentioned. In a number of instances the plants had been in blossom for several days before the notes were taken. It will be seen that the dates for 1889 and '90 were nearly the same, while those for 1891 were in most instances from ten days to two weeks later. From this table may be gained a fair idea of the variableness of the spring season in Vigo County.

	1889.	1890.	1891.
Acer rubrum L., Red Maple	Mar. 10.	Feb. 16.	Feb. 21.
Acer saccharinum L., Soft or White Maple	Mar. 13.	Feb. 16.	?
Draba caroliniana Walt., Whitlow Grass	Mar. 14.	Mar. 21.	Mar. 30.
Cardamine douglassii (Torr.), Purple Cardamine	Mar. 23.	Feb. 9.	Mar. 18.
Bursa bursa-pastoris (L.), Shepherd's Purse	Mar. 10.	Apr. 5.	Apr. 12.
Erigenia bulbosa (Michx.), Turkey Pea	Mar. 16.	Mar. 22.	Mar. 18.
Corylus americana (Walt.), Hazlenut	Mar. 16.	?	Apr. 1.
Hepatica acuta (Pursh.), Liverwort	Mar. 17.	Mar. 21.	Apr. 1.
Sanguinaria canadensis L., Bloodroot	Mar. 17.	Mar. 26.	Apr. 7.
Viola tenella Muhl., Wild Pansy	Mar. 17.	Apr. 27.	Apr. 16.
Ranunculus abortivus L., Small-flowered Crowfoot	Mar. 17.	Apr. 5.	Apr. 16.
Dentaria laciniata Muhl., Toothwort	Mar. 23.	Mar. 22.	Apr. 12.
Claytonia virginica L., Spring Beauty	Mar. 23.	Mar. 22.	Mar. 29.
Caltha palustris L., Marsh Marigold	Apr. 6.	Mar. 26.	Apr. 7.
Mertensia virginica (L.), Bluebells	Apr. 1.	Apr. 5.	Apr. 16.
Viola obliqua Hill, Common Blue Violet	Apr. 6.	Apr. 5.	Apr. 14.

	1889.	1890.	1891.
Phlox divaricata L., Sweet William	Apr. 6.	Apr. 5.	Apr. 18.
Erythronium americanum Ker., Yellow Adder's Tongue	Apr. 6.	Apr. 5.	Apr. 12.
Isopyrum biternatum (Raf.), False Rue-anemone	Apr. 2.	Apr. 5.	Apr. 12.
Phlox bifida Beck, Dwarf Phlox	Apr. 7.	Apr. 13.	Apr. 17.
Bicuculla cucullaria L., Dutchman's Breeches	Apr. 10.	Apr. 5.	Apr. 12.
Trillium sessile L., Sessile Trillium	Apr. 10.	Apr. 8.	Apr. 18.
Trillium recurvatum Beck, Purple Trillium	Apr. 10.	Apr. 10.	Apr. 18.
Alsine pubera (Michx.), Great Chickweed	Apr. 13.	Apr. 5.	Apr. 18.
Taraxacum taraxacum (L.), Dandelion	Apr. 13.	Apr. 5.	Apr. 18.
Viola pubescens Ait., Downy Yellow Violet	Apr. 13.	Apr. 13.	Apr. 18.
Viola striata Ait., Pale Violet	Apr. 13.	Apr. 13.	Apr. 18.
Cercis canadensis L., Red Bud	Apr. 13.	Apr. 20.	Apr. 19.
Ribes gracile Michx., Missouri Gooseberry	Apr. 13.	Apr. 8.	Apr. 16.
Capnoides flavulum (Raf.), Yellow Corydalis	Apr. 13.	Apr. 13.	Apr. 17.
Delphinium tricorne Michx., Dwarf Blue Larkspur	Apr. 13.	Apr. 13.	Apr. 21.
Bicuculla canadensis (Goldie.), Squirrel Corn	Apr. 13.	Apr. 5.	?
Erythronium albidum Nutt., White Adder's Tongue	Apr. 13.	Apr. 8.	?
Collinsia verna Nutt., Innocence	Apr. 13.	Apr. 13.	Apr. 26.
Senecio obovatum Muhl., Ragwort	Apr. 17.	Apr. 13.	Apr. 23.
Syndesmon thalictroides (L.), Rue-anemone	Apr. 17.	Apr. 5.	Apr. 28.
Benzoin benzoin (L.), Spice-bush	Apr. 10.	Apr. 5.	Apr. 12.
Ranunculus septentrionalis Poir., Creeping Buttercup	Apr. 13.	Apr. 13.	Apr. 19.
Polemonium reptans L., Greek Valerian	Apr. 13.	Apr. 13.	Apr. 19.
Glecoma hederacea L., Ground Ivy	?	Apr. 13.	Apr. 17.
Stylophorum diphyllum (Michx.), Yellow Celandine Poppy	Apr. 17.	Apr. 19.	Apr. 25.
Sassafras sassafras (L.), Sassafras	Apr. 20.	Apr. 13.	Apr. 25.
Geranium maculatum L., Wild Cranesbill	Apr. 20.	Apr. 27.	?
Senecio aureus L., Golden Ragwort	Apr. 20.	Apr. 27.	?
Ribes cynosbati L., Prickly Wild Gooseberry	Apr. 20.	Apr. 13.	Apr. 21.
Pyrus malus L., Wild Apple	?	Apr. 20.	Apr. 28.
Erigeron philadelphicus L., Common Fleabane	Apr. 20.	Apr. 27.	May 6.
Acer negundo L., Box Elder	Apr. 20.	Apr. 20.	Apr. 16.
Descurainia pinnata (Walt.), Tansy Mustard	Apr. 20.	Apr. 20.	Apr. 19.
Geum vernum (Raf.), Spring Avens	Apr. 20.	Apr. 27.	?
Mitella diphylla L., Bishop's Cap	Apr. 21.	Apr. 21.	Apr. 25.
Prunus americana Marsh., Wild Plum	Apr. 21.	?	Apr. 21.
Veronica arvensis L., Corn Speedwell	Apr. 21.	Apr. 13.	Apr. 28.
Cardamine hirsuta L., Small Bitter Cress	Apr. 21.	Apr. 13.	Apr. 19.
Cerastium longipedunculatum Muhl., Nodding Chickweed	Apr. 21.	Apr. 20.	Apr. 18.
Asimina triloba (L.), Papaw	?	Apr. 29.	Apr. 25.
Craetagus mollis (T. & G.), Red Haw	Apr. 23.	Apr. 30.	?
Æsculus glabra Willd., Buckeye	Apr. 20.	Apr. 29.	?
Phacelia purshii Buckl., Phacelia	Apr. 28.	May 3.	May 3.
Pedicularis canadensis L., Lousewort	Apr. 28.	?	Apr. 28.
Caulophyllum thalictroides (L.), Blue Cohosh	Apr. 28.	Apr. 19.	?
Sisyrinchium bermudiana L., Blue-eyed Grass	Apr. 27.	May 3.	Apr. 28.
Hicoria ovata (Mill.), Shellbark Hickory	Apr. 30.	?	May 3.
Cornus florida L., Flowering Dogwood	Apr. 28.	May 3.	Apr. 28.
Podophyllum peltatum L., May Apple	?	Apr. 27.	May 3.
Orchis spectabilis L., Showy Orchis	Apr. 28.	?	May 3.
Fragaria vesca L., Wild Strawberry	?	Apr. 27.	Apr. 28.
Ranunculus recurvatus Poir., Hooked Crowfoot	Apr. 28.	Apr. 27.	May 3.
Rumex acetosella L., Field Sorrel	?	Apr. 29.	May 6.
Trifolium repens L., White Clover	Apr. 30.	May 3.	May 17.

PARASITIC PLANTS.

The list of flowering plants devoid of leaves and true roots, and deriving their nourishment from other vegetation, is a large one in proportion to the number of species in the county. Belonging to it we find the Corpse Plant, *Monotropa uniflora* L., and the Pine-sap, *Hypopitys hypopitys* (L.), pale, delicate forms, which rear their slender stems from masses of decaying vegetation about the roots of other plants in high, dry woodlands; the Beech-drops, *Epiphegus virginiana* (L.), and the Squaw-root, *Conopholis americana* (L.), the former common on the roots of beech trees, the latter scarce among fallen leaves in rich, open woods; the Broom-rape, *Orobanche ludoviciana* Nutt., and its near relative, the One-flowered Cancer-root, *Thalesia uniflora* (L.), both rare, the former parasitic on the roots of the great horse-weed, and the latter growing in damp, decaying vegetable mold, and finally the two Dodders, *Cuscuta gronovii* Willd., and *C. polygonorum* Engelm., both common in low, alluvial soil, where they twine their yellow stems about the stalks of asters, wild sunflowers and the greater ragweed, and derive therefrom the nourishment for their existence.

VIGO COUNTY PLANTS NEW TO THE STATE LIST.

Among the plants occurring in Vigo County are thirty-three species which have not before been recorded as growing in Indiana. Of a number of them the range, as given in Gray's Manual, is "Illinois and westward." Of the others the general range, for the most part, includes Indiana, though as yet no one has heretofore happened upon them within the State.

The list of them is as follows:

1. *Potamogeton diversifolius* Raf., Rafinesque's Pondweed.
2. *Potamogeton spirillus* Tuckerm., Spiral Pondweed.
3. *Zannichellia palustris* L., Horned Pondweed.
4. *Echinodorus cordifolius* (L.) Griseb., Upright Bur-head.
5. *Panicum minus* Muhl., Wood Panicum.
6. *Panicum pubescens* Lam., Hairy Panicum.
7. *Homalocenchrus lenticularis* (Michx.) Scribn., Catch-fly Grass.
8. *Sporobolus asper* (Michx.) Kunth., Rough Rush Grass.
9. *Agrostis intermedia* Scribn., Upland Bent Grass.
10. *Polygonum ramosissimum* Michx., Bushy Knotweed.
11. *Chenopodium boscianum* Moq., Bosc's Goosefoot.
12. *Anemone caroliniana* Walt., Carolina Anemone.
13. *Ranunculus purshii* Richards, Pursh's Yellow Water Crowfoot.
14. *Lepidium intermedium* A. Gray, Peppergrass.

15. *Geum macrophyllum* Willd., Round-leaved Avens.
16. *Sanguisorba canadensis* L., Canadian Burnet.
17. *Lespedeza angustifolia* (Pursh.) Ell., Narrow-leaved Bush Clover.
18. *Falcata pitcheri* (T. & G.) Kuntze, Large-leaved Hog Peanut.
19. *Euphorbia heterophylla* L., Diverse-leaved Spurge.
20. *Hypericum densiflorum* Pursh., Dense-flowered St. John's Wort.
21. *Oenothera sinuata* L., Sinuate-leaved Evening Primrose.
22. *Myriophyllum verticillatum* L., Water Milfoil.
23. *Macrocalyx nyctelea* (L.) Kuntze, Ellis' Waterleaf.
24. *Trichostema dichotomum* L , Blue Curls.
25. *Orobanche ludoviciana* Nutt., Broom Rape.
26. *Plantago aristata* Michx., Awned Plantain.
27. *Chrysopsis villosa* (Pursh.) Nutt., Golden Aster.
28. *Solidago rigidiuscula* (T. & G.) Porter, Goldenrod.
29. *Solidago speciosa* Nutt., Handsome Goldenrod.
30. *Aster drummondi* Lindl., Drummond's Aster.
31. *Ambrosia bidentata* Michx., Two-toothed Ragweed.
32. *Hymenopappus caroliniensis* (Lam.) Porter, Carolina Hymenopappus.
33. *Senecio lobatus* Pers., Butterweed.

WEEDS OF VIGO COUNTY.

What is a weed? How does it differ from a wild flower? These questions are often asked by persons who are beginning the study of botany, and pupils have been known to put aside a specimen with a look of disgust, saying that they "did not want to study that nasty weed."

There is, of course, no difference, botanically speaking, between a weed and a wild flower, save that of comparative abundance. Some of our most common weeds are among the most handsome of our wild flowers, for example, the iron-weed, thistle and ox-eye daisy. They well illustrate the truth of that old saying, that "Familiarity breeds contempt," for we have become so familiar with their appearance that we daily pass them by unnoticed. Were they as rare as the showy orchis and wild columbine they would no longer be called "weeds," but "wild flowers," and would, perhaps, be cultivated for ornament, just as among half the collections of house plants in Vigo County are found species of cacti, which are by no means rarities to the natives of Texas and New Mexico.

Defining a weed as a useless plant, growing wild in cultivated grounds, pastures and meadows, of sufficient size to be easily noticeable and of sufficient abundance to be injurious to the farmer, we find eighty-two species occurring in Vigo County.

A few years ago the writer published in the *Indiana Farmer** a list of what he then considered the twenty worst weeds growing in western Indiana, together with information concerning the many ways in which weeds are distributed from one section of country to another. That list, with the species named in the order of their injuriousness, together with the original home of each, was as follows:

1. *Ambrosia artemisiæfolia* L., Ragweed, United States.
2. *Setaria glauca* Beauv., Foxtail, Europe.
3. *Ambrosia trifida* L., Great Ragweed, United States.
4. *Vernonia fasciculata* Michx., Ironweed, United States.
5. *Amarantus retroflexus* L., Pigweed, Tropical America.
6. *Erigeron canadense* L., Horseweed, United States.
7. *Convolvulus sepium* L., Bracted Bindweed, United States.
8. *Xanthium canadense* Mill., Cocklebur, United States.
9. *Erigeron annuus* L., Whitetop, United States.
10. *Chenopodium album* L., Lamb's Quarters, Europe.
11. *Cnicus lanceolatus* Hoffm., Common Thistle, Europe.
12. *Portulaca oleracea* L., Purslane, Europe.
13. *Cenchrus tribuloides* L , Bur-grass, United States.
14. *Bidens frondosa* L., Beggar's Ticks, United States.
15. *Panicum sanguinale* L., Crab-grass, Europe.
16. *Datura stramonium* L., Jimson Weed, Asia.
17. *Polygonum persicaria* L., Smartweed, Europe.
18. *Datura tatula* L., Purple Jimson, Tropical America.
19. *Arctium lappa* L., Burdock, Europe.
20. *Solidago canadensis* L., Golden rod, United States.

Seven years' additional study of the flora has changed but little the writer's opinion concerning this list. It would be more correct, perhaps, to place the ironweed (No. 4) before the great ragweed (No. 3) and to drop the bracted bindweed (No. 7) from the list, replacing it with the prickly lettuce (*Lactuca scariola* L.), another European alien, which in recent years has spread throughout the county with great rapidity. The field sorrel (*Rumex acetosella* L.), also of European origin, is probably more troublesome than the burdock (No. 19), and the corn cockle (*Lychnis githago* L.), also from Europe, will, as a weed, probably outrank the golden-rod (No. 20).

These changes made, the list would contain eight plants native to our country and twelve introduced from foreign shores.

As Grant Allen has well said, "the American soil seems to suit exactly those weeds which are the offscourings and refuse of civilization in all countries. In civilized, cultivated and inhabited New England, and as far inland, at least, as the Mississippi, the prevailing vegetation is the vegetation of Central Europe, and that at its weediest. The daisy, the primrose, the cowslip and the daffodil have stayed at home; the weeds have gone to colonize the New World. For thistles and burdock, dog fennel and dead nettle, hound's tongue and stick-seed, catnip and dandelion, ox-eye daisy and cocklebur, America easily licks all creation. All the dusty, noisome and malodorous pests of all the world seem there to revel in one grand, congenial, democratic orgy."

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*March 8, 1890.

"What is the best method of ridding ourselves of these foreign weeds?" is the question we hear asked by the practical farmer. In the writer's opinion, there is no method. They are here, and here to stay. The farmers of the future must wage an eternal warfare against them, for they have secured a foothold which can not be overcome. There was a time when but one, two, or a dozen plants of each species existed in the State. Then was the time to have successfully quarantined that species by destroying those pioneers. The few persons on whose lands they appeared neglected them, and every gardener, every farmer, yea, every land-owner in the State, must henceforth, now and forever, pay the penalty of that neglect by continued hoeing, plowing and mowing to keep these weeds in subjugation. As long as the rudiments of botany are not taught in the common schools of this State the average farmer will be unable to tell whether a new plant that makes its appearance upon his land should be allowed to grow or not; indeed, in many instances, he will not know that a new plant is there until it becomes too abundant to be overcome. Put a high school into each township in the State; teach the elements of botany therein, and then, and not till then, may we hope that the farmers of the future will be on the lookout for all new plants; will be able at once to judge their relative injuriousness, and will destroy, before they have time to ripen their seeds, those species which, if allowed to spread, will become a curse to the State.

NOMENCLATURE.

The nomenclature and arrangement of the present list is that of the new "*List of Pteridophyta and Spermatophyta growing without cultivation in Northeastern North America,*" prepared by a Committee of the Botanical Club of the American Association for the Advancement of Science, and published in 1894 as the fifth volume of the Memoirs of the Torrey Botanical Club.

This check-list is based on the belief that "the order of nature is an order of evolution and development from the more simple to the more complex." It, therefore, begins with the lowest forms of the plants included, the ferns, and ends with the highest, the members of the family Compositæ. Moreover, the law of priority has been strictly followed, and the first describer of a species is given the credit therefor instead of the person who first placed it in the genus now adopted, as has been the custom in Gray's Manual and other recent botanical works.

This list is now the recognized standard among botanists in the United States, and has been followed by Britton and Brown in their new "Illustrated Flora," now being issued. In the present catalogue of Vigo County plants the only deviation from the new check-list is that of beginning each specific name with a small letter, whatever its origin, that being the rule in zoölogical literature, and, in the writer's opinion, the proper one to pursue. Where the name adopted in the new check-list differs from that in Gray's Manual, sixth edition, the one used in the latter work is placed in parenthesis as a synonym in the first line following the common name of the plant. The number in parenthesis is the number of the plant in the check-list.

The present list is based upon the collections made by myself during my seven years' residence in Vigo County. All species included, except a few of the more common ones, like the dandelion and mullein, are represented by specimens, either in the herbarium of DePauw University, which, in 1893, came into possession of several hundred Vigo County plants collected by me, or by specimens in my private herbarium. Species represented in the DePauw herbarium are preceded by an asterisk (*). The date given is the earliest of those recorded in my notes, or those of Dr. Evermann, for the blooming of the plant in question. If the season is a forward one specimens of the plant will doubtless be found in flower at the date given; if backward, the blooming will be from a week to two weeks later.

I am under obligations to Dr. B. W. Evermann, formerly professor of botany in the State Normal School, for the use of notes pertaining to the locality and date of flowering of a number of the species; to Dr. L. M. Underwood, of Columbia University, New York, for suggestions regarding the nomenclature adopted, and to Dr. J. T. Scovell and O. F. Fidlar, of Terre Haute, for aid in collecting certain species in the fall of 1896. Messrs. J. M. and Stanley Coulter have also verified a number of species for me, and to them my thanks are due for the service rendered.

CATALOGUE.

PTERIDOPHYTA.

"In the entire vegetable world there are probably no forms of growth that attract more general notice than the ferns. Delicate in foliage, they are sought for cultivation in conservatories and Wardian cases, and when dried and pressed add to the culture of many a domestic circle by serving as household decorations. They furnish to botanists a broad and inviting field for investigation, and he who examines their more minute structure with the microscope will find deeper and still more mysterious relations than those revealed to the unaided eye. Ferns thus appeal to the scientific element of man's nature as well as to the æsthetic, and while they highly gratify the taste, they furnish food for the intellect in a like degree."—*Underwood.**

OPHIOGLOSSACEÆ. Adder's Tongue Family.

1. BOTRYCHIUM Sw. Schrad.

1. (6) B. TERNATUM (Thunb.) Sw. Schrad. Ternate Grape Fern.
Upland shaded banks in rich soil; rare.
Southwest of Ferrell's woods; September 20, 1889.

The form taken was the one usually known as var. *obliquum* Milde—a foot high, with the fruiting portion more compound, and the sterile segment with the divisions oblong and oblique at the base.

2. (7.) B. VIRGINIANUM (L.) Sw. Schrad. Virginia Grape Fern.
Rich open woods; frequent. May 9.

FILICES. Fern Family.

2. ADIANTUM L.

3. (12.) A. PEDATUM L. Maiden-hair Fern.
Moist hillside thickets and woods; frequent. July 6.

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*Our Native Ferns and Their Allies. (Introduction.)

3. PTERIS L.

4. (13.) P. AQUILINA L. Common Brake. Eagle Fern.
Frequent at Heckland in sandy soil, alonge fence rows and borders of raw prairie. Not noted elsewhere. June 8.

4. ASPLENIUM L.

5.* (26.) A. ANGUSTIFOLIUM Michx. Narrow-leaved Spleenwort.
Sides of ravines; frequent. July 10.

6.* (34.) A. PLATYNEURON (L.) Oakes. Ebony Spleenwort.
(*A. ebeneum* Ait.)
Sides of ravines and damp wooded slopes; scarce.
Honey Creek. Coal Creek. June 30.

5. PHEGOPTERIS Fee.

7. (42.) P. HEXAGONOPTERA (Michx.) Fee. Beech Fern.
Wooded hillsides, in moist, rich soil; scarce.
Coal Creek hills. July 2.

6. DRYOPTERIS Adans.

(*Aspidium* Sw. Schrad.)

8. (44.) D. ACROSTICHOIDES (Michx.) Kuntze. Christmas Fern.
(*A. acrostichoides* Swartz.)
Sides of ravines in rich soil; common.
Specimens with fruit can be gathered any month in the year.

9. (53.) D. MARGINALIS (L.) A. Gray. Evergreen Wood-fern.
(*A. marginale* Swartz.)
Sides of ravines; scarce. Coal Creek. (*Evermann.*)

10.* (57). D. SPINULOSA INTERMEDIA (Muhl.) Underw.
(*A. spinulosum intermedium** D. C. Eaton.)
Moist, dense woods; scarce. Ferrell's. Heckland. July 14.

11. (58.) D. THELYPTERIS (L.) A. Gray. Marsh Shield Fern.
(*A. thelypteris* Swartz.)
Low wet meadows and prairies; common. July 30.

7. CYSTOPTERIS Bernhardi.

12. (59.) C. BULBIFERA (L.) Bernh. Bladder Fern.
Rocky ravines; scarce. (*Evermann.*)
A curious species; the long, tapering fronds with numerous small bulbs along the under side of rachis.

13.* (60.) C. FRAGILIS (L.) Bernh. Bottle Cystopteris. Bladder Fern.
Rich wooded slopes; scarce. North Sand Hill. June 1.

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* See Proc. Ind. Acad. Sci., 1893, 256.

8. ONOCLEA L.

14. (62.) O. **SENSIBILIS** L. Sensitive Fern.
Dense, moist woods; frequent. May 28.

9. OSMUNDA L.

15. (74) O. **CINNAMOMEA** L. Cinnamon Fern.
Low, wet prairie swamps; scarce. May 28.
Heckland.

16. (75.) O. **CLAYTONIANA** L. Interrupted Fern.
Swamps and shaded banks; scarce. May 20.
Ferrell's. Old canal below Spring Hill.

17. (76.) O. **REGALIS** L. Flowering Fern.
Low wet woods and marshes; scarce.
Heckland. Ferrell's. May 13.

EQUISETACEÆ. Horse-tail Family.

10. EQUISETUM L.

18. (81.) E. **ARVENSE** L. Common Horse-tail.
Moist, gravelly banks; frequent. April 14.

19.* (82.) E. **FLUVIATILE** L. Swamp Horse-tail.
(*E. limosum* L.)
Margins of ponds in shallow water. Noted only at Goose Pond, where it is very common. May 3.

20. (83.) E. **HYEMALE** L. Scouring Rush. Shave Grass.
Wet, sandy banks; frequent along the railways and canals. May 5.

SPERMATOPHYTA.

GYMNOSPERMÆ.

CONIFERÆ. Pine Family.

11. JUNIPERUS L.

21. (140.) J. **COMMUNIS** L. Common Juniper.
Dry or sandy hillsides; scarce.
Hipple's Coal-mine woods. Sand Hill. May 25.

22. (143.) J. **VIRGINIANA** L. Red Cedar.
Old fields and roadsides; frequent.
A shrub in Vigo County. April 20.

MONOCOTYLEDONES.

TYPHACEÆ. Cat-tail Family.

12. TYPHA L.

23. (146.) T. LATIFOLIA L. Common Cat-tail. Reed Mace. Flag.
Marshes and large ditches; frequent. May 24.

SPARGANIACEÆ. Bur-reed Family.

13. SPARGANIUM L.

24. (149.) S EURYCARPUM Engelm. Bur-reed.
Swamps and borders of ponds; scarce. June 14.
Heckland. Goose Pond.

NAIADACEÆ. Pond-weed Family.

14. POTAMOGETON* L.

25.* (159.) P. DIVERSIFOLIUS Raf. Rafinesque's Pondweed.
(*P. hybridus* Michx.)
Pond south of fair ground; frequent locally. October 3, 1889.
The first record for the State.

26. (162.) P. FOLIOSUS Raf. Leafy Pondweed.
(*P. pauciflorus* Pursh.)
Shallow ponds and ditches; frequent. June 10.

27. (180.) P. NATANS L. Floating Pondweed.
Ditches and ponds; frequent. June 25.

28.* (196.) P. SPIRILLUS Tuckerm. Spiral Pondweed.
Five-Mile Pond; scarce. July 19.
The first record for the State.

15. ZANNICHELLIA L.

29. (202.) Z. PALUSTRIS L. Horned Pondweed.

This species grew in abundance in the pond south of the blast furnace, at Terre Haute, in the years 1889–'93. The surface of this pond seldom froze in winter on account of the warm stream of water from the furnace flowing into it. Since the furnace shut down the pond has dried up, and the plant has disappeared.

The first record for the State.

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*The members of this genus have not been thoroughly collected, and a number of additional forms will doubtless be found in the ponds and streams.

ALISMACEÆ. Water-Plantain Family.

16. ALISMA L.

30. (212.) A. PLANTAGO-AQUATICA L. Water-Plantain.
(*A. plantago* L.)
Ditches and borders of ponds; common. July 3.

17. ECHINODORUS Engelm.

31.* (214.) E. CORDIFOLIUS (L.) Griseb. Upright Bur-head.
(*E. rostratus* Engelm.)
Noted only about the borders of Conover's Pond. In 1889 it grew very abundantly on the mud flats on south side of pond; less frequent since.
The first record for the State.

18. SAGITTARIA L.

32. (223.) S. LATIFOLIA Wild. Broad-leaved Arrow-head.
(*S. variabilis* Engelm.)
Ponds, ditches and slow flowing streams; common.
Exceedingly variable in size and shape of leaf. June 10.

33.* (227.) S. RIGIDA Pursh. Sessile-fruiting. Arrow-head.
(*S. heterophylla* Pursh.)
Borders of ponds; frequent. May 22.

"Specimens differ greatly in size and form of leaf, the difference depending largely on the habitat of the plant. When growing in deep pools or running streams the petioles become thick, rigid and elongated, with long, narrowly lanceolate, spongy blades, or the tapering attenuate phyllodia are leafless. This is the *S. heterophylla rigida* of Gray's Manual, 6th ed."* This form occurs sparingly in Vigo County, having been taken at the Goose Pond, June 22, 1890.

HYDROCHARITACEÆ. Frogs-bit Family.

19. UDORA Nutt.

(*Elodea* Michx.)

34. (231.) U. CANADENSIS (Michx.) Nutt. Waterweed. Ditch Moss.
(*Elodea canadensis* Michx.)
Abundant in Five-Mile and Goose Ponds. May 28.

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* Jared G. Smith, Sixth Ann. Rep. Mo. Bot. Garden, 1895, 45.

20. VALLISNERIA L.

35. (232.) V. SPIRALIS L. Tape Grass. Eel Grass.
Ponds; scarce.
Pond north side of Van. railway near Beach's. South Sand Hill.

GRAMINEÆ. Grass Family.

21. ANDROPOGON L.

(Includes *Chrysopogon* Trin.)

36.* (246.) A. NUTANS AVENACEUS (Michx.) Hack. Indian Grass. Wood Grass.

(*C. nutans* Benth.)

Sandy waste places and hillsides; frequent.

Varies in height from three to ten feet. Aug. 5.

37. (247.) A. PROVINCIALIS Lam. Beard-grass. Forked Spike.

(*A. furcatus* Muhl.)

Dry, sandy banks and hillsides; common. August 2.

38. (250.) A. SCOPARIUS Michx. Broom Beard-grass.
With the preceding; common. July 28.

The culms of each of the last two, 10 to 25 in number, spring from dense clumps of root leaves.

39. (251.) A. VIRGINICUS L. Virginia Beard-grass.
Sandy and gravelly banks; scarce.
Gravel pit near Van. railway. September 6, 1887.

22. PASPALUM L.

40.* (261.) P. SETACEUM Michx. Slender Paspalum.
Sandy waste places; common. August 17.

40a.* (261a.) P. CILIATIFOLIUM Michx. Ciliate-leaved Paspalum.
With the above, but less common. August 10.

23. PANICUM L.

41. (266.) P. AUTUMNALE Bosc. Diffuse Panicum.
Sandy hillsides and banks along railways; frequent. Common on the hillside at Five-mile Pond, where it grows in dense tufts. August 10.

The flowers of this grass are, when in their prime, a grayish-purple in color, and, when wet with dew, reflect the morning sunlight in a peculiar and pleasing manner.

Recorded before in Indiana only from Lake County.

42. (267.) P. CAPILLARE L Old Witch Grass.
Sandy banks and borders of fields; common. August 12.

This species is a common tumble-weed, and oftentimes in late autumn fence corners are filled to a depth of several feet with the broken stems which have been driven long distances before the wind.

42a. (268.) P. MINUS Muhl. Wood Panicum.
A specimen, so named for me by Mr. Geo. V. Nash, of Columbia University, was taken from a dry hillside in Hipple's Coal-mine woods, where it is frequent.
Not before recorded from Indiana.

43 * (271.) P. CLANDESTINUM L. Hispid Panicum.
Banks of railways and low rich woods; frequent. June 28.

44.* (274.) P. CRUS-GALLI L. Barn-yard Grass.
Rich, moist waste places; common. August 11.

In fruit sometimes when but two inches high.

45.* (277.) P. DICHOTOMUM L. Forked Panicum.
Dry, open woods and gravelly banks; common. May 25.

46. (288a.) P. PORTERIANUM Nash. Porter's Panicum.
(*P latifolium* L)
Moist thickets and open woods; frequent. June 20.

47. (289.) P. PROLIFERUM Lam. Spreading Panicum.
Low, wet, sandy or gravelly places; frequent. August 14.

The culms from the same root vary much in length and number of branches, and are usually prostrate, and spreading irregularly.

48. (289a.) P. PUBESCENS Lam. Hairy Panicum.
A species so named for me by Mr. Nash. It grows commonly along the railway at Heckland and in Beach's woods.
The first record for the State.

49.* (291.) P. SANGUINALE L. Crab Grass. Finger Grass.
Waste and cultivated grounds; abundant.

Dry, sandy fields in which early crops are cultivated are overrun in late autumn with this foreign grass. August 4.

50.* (295.) P. VIRGATUM L. Tall, Smooth Panicum.
Sandy banks; scarce, except at Heckland, where it is frequent along the railway.

Our tallest species of the genus. August 20.

24. CHAMÆRAPHIS R. Br.
(*Setaria* Beauv.)

51. (300.) C. GLAUCA (L.) Kuntze. Foxtail. Pigeon Grass.
(*Setaria glauca* Beauv.)
Cultivated grounds and stubble fields; abundant. June 25.

52. (301.) C. ITALICA (L.) Kuntze. Bengal Grass. Millet.
(*Setaria italica* Kunth.)
Waste places along the old canal; scarce. June 10.

53.* (304.) C. VIRIDIS (L.) Porter. Green Foxtail. Bottle Grass.
(*Setaria viridis* Beauv.)
Waste or cultivated grounds; frequent. July 3.

25. CENCHRUS L.

54. (305.) C. TRIBULOIDES L. Sand Burs. Bur Grass. Hedgehog Grass.
Sandy banks along the river, railways and canal; common.

A tribulation, indeed, to barefooted boys. August 5.

26. ZIZANIA L.

55. (307.) Z. AQUATICA L Indian Rice. Water Oats
Shallow water near margin of ponds; scarce.

In 1889, at the time the Five-Mile Pond contained so many specimens of *Nelumbo lutea* Pers., this grass grew in abundance near its northern border. The stems were many of them ten to twelve feet in height, and the leaves often a yard long. Like the Nelumbo, it has practically disappeared in recent years. Not noted elsewhere.

27. HOMALOCENCHRUS Mieg.
(*Leersia* Swartz.)

56. (308.) H. LENTICULARIS (Michx.) Scribn. Catch-fly Grass.
(*L. lenticularis* Michx.)
Taken but once, October 6, 1893, from the margin of Five-Mile Pond.

The first record for the State.

57.* (309.) H. ORYZOIDES (L.) Poll. Rice Cut-grass.
(*L. oryzoides* Swartz)
Ditches and borders of swamps; common. July 27.

58.* (310.) H. VIRGINICUS (Willd.) Britton. White Grass.
(*L. virginica* Willd.)
Damp woods and moist, shaded banks; frequent. August 10.

27a. ANTHOXANTHUM L.

58a. (314.) A. ODORATUM L. Sweet Vernal-grass.
Meadows and borders of cultivated fields; frequent July 1.

28. ARISTIDA L.

59. (319.) A. DICHOTOMA Michx. Poverty Grass.
Borders of sandy fields and banks of railways; frequent. August 17.

29. MUHLENBERGIA Schreb.

60.* (343.) M. DIFFUSA Schreb. Drop-seed. Nimble Will.
Dry woods, fence rows, etc.; common. August 14.

61. (345.) M. MEXICANA (L.) Trin. Drop-seed Grass.
Low, moist, sandy soil; common. July 20.

62. (350.) M. SYLVATICA (Torr.) A. Gray. Wood Muhlenbergia.
Low, damp woods; frequent. July 25.

30. PHLEUM L.

63. (355.) P. PRATENSE L. Timothy.
Roadsides, fence rows, etc., escaped from cultivation; common. June 10.

31. SPOROBOLUS R. Br.

64.* (363.) S. ASPER (Michx.) Kunth. Rough Rush-grass.
Sandy banks and hillsides; scarce. August 30.
Along the Van. railway near the gravel pit.
The first record for the State.

35. CINNA L.

65. (379.) C. ARUNDINACEA L. Wood-reed Grass.
Moist shaded banks; frequent. July 15.

33. AGROSTIS L.

66. (383.) A. ALBA VULGARIS (With.) Thurb. Red Top.
Moist, rich soil along roadsides and in meadows; common.

67.* (389.) A. HIEMALIS (Walt.) B. S. P. Hair Grass.
(*A. scabra* Willd.)
Borders of prairies; scarce. June 25.
Heckland.

67a.* (389a.) A. INTERMEDIA Scribn. Upland Bent-grass.
Hillside near Five-Mile Pond; scarce. August 30.
The first record for the State; the species having been described from Tennessee in 1894.

68. (390.) A. PERENNANS (Walt.) Tuckerm. Thin-grass.
Damp, shady places; frequent. July 17.

34. CALAMAGROSTIS Adans.

69. (393.) C. CANADENSIS (Michx.) Beauv. Blue-joint Grass.
Low, wet meadows and prairies; frequent. July 6.

35. PHRAGMITES Trin.

70. (447.) P. PHRAGMITES (L.) Karst. Reed.
(*P. communis* Trin.)
Ditch near Heckland Station, where it grows 14 feet high.
Not seen elsewhere. Sept. 5.

36. SIEGLINGIA Bernh.
(*Triodia* R. Br.)

71.* (449.) S. SESLERIOIDES (Michx.) Scribn. Tall Red-top.
(*T. cuprea* Jacq.)
Sandy banks and borders of fields; scarce. Aug. 5.
Heckland, along the railroad; canal near Conover's Pond.

The purple spreading panicle is very handsome, as handsome goes, among grasses.

37. ERAGROSTIS Beauv.

71a.* (453.) E. CAROLINIANA (Spreng.) Scribn.
Dry, sandy soil; frequent. August 14.

72. (456.) E. FRANKII Steud.
Low, sandy, cultivated ground; frequent. August 15.

A slender, low, tufted species.

73. (457.) E. HYPNOIDES (Lam.) B. S. P. Creeping Eragrostis.
(*E. reptans* Nees.)
Gravel bars and sandy banks; frequent. August 3.

74.* (458.) E. MAJOR Host. Strong-scented Eragrostis.
Sandy waste places; common. June 20.

Handsome. Varies greatly in size, fruiting specimens ranging from two inches to two feet in height.

75. (459.) E. PECTINACEA (Michx.) Steud. Purple Eragrostis.
Sandy hillsides; frequent. August 10.

76. (461.) E. PILOSA (L.) Beauv. Tufted Eragrostis.
Gravelly banks along railways; scarce.
Van. railway, near fair grounds. September 28, 1889.

38. EATONIA Raf.

77. (467.) E. PENNSYLVANICA (DC.) A. Gray.
Moist, open woods; frequent. June 18.

39. DACTYLIS L.

78. (485.) D. GLOMERATA L. Orchard Grass.
Borders of fields, roadsides, yards, etc.; frequent. June 11.

40. POA L.

79. (489.) P. ANNUA L.. Low Spear-grass.
Yards and roadsides; common. April 28.

80. (497.) P. FLAVA L. False Red-top. Fowl Meadow-grass.
(*P. serotina* Ehrh.)
Moist meadows; frequent. July 16.

81. (503.) P. PRATENSIS L. Kentucky Blue-grass. June Grass.
Roadsides and pastures; abundant. May 14.

Probably the most valuable wild grass known to man.

41. PANICULARIA Fabr.
(*Glyceria* R. Br.)

82. (522.) P. NERVATA (Willd.) Kuntze. Nerved Manna grass.
(*G. nervata* Trin.)
Low moist grounds; frequent. May 25.

42. FESTUCA L.

83. (530.) F. NUTANS Willd. Nodding Fescue-grass.
Dry, wooded hillsides; scarce. July 17.
Coal Creek. Beach's.

43. BROMUS L.

84. (541.) B. CILIATUS L. Wood Chess.
Moist, sandy banks; frequent. July 3.

Our tallest species, and the only native one thus far found in the county.

85. (548.) B. RACEMOSUS L. Upright Chess.
Banks of river and along canal; scarce. June 28.

86.* (549.) B. SECALINUS L. Cheat. Chess.
Borders of grain fields and fence rows; frequent. May 25.

43a. LOLIUM L.

86a. (554.) L. PERENNE L. Ray-grass. Rye-grass.
Borders of cultivated fields; frequent. July 10.

43b. AGROPYRON J. Gærtn.

86b. (561.) A. REPENS (L.) Beauv. Couch-grass. Quitch-grass.
Old fields and cultivated grounds; common. July 20.

A vile weed which is yearly becoming more troublesome.

44. ELYMUS L.

87.* (572) E. CANADENSIS L. Nodding Wild Rye.
Sandy banks of railways and canal; frequent. August 5.

88.* (580.) E. VIRGINICUS L. Wild Rye.
Banks of Wabash below Ft. Harrison, in sandy, shaded soil; scarce. August 14.

CYPERACEÆ. Sedge Family.

45. CYPERUS L.

89. (589.) C. DIANDRUS Torr. Galingale.
Low, wet or sandy grounds; common. August 5.

90. (616.) C. SPECIOSUS Vahl. Michaux's Cyperus.
Low, sandy soil; scarce.

Varies much in size. A specimen taken at Heckland, October 14, 1896, had six umbels, the stalk of each apparently springing from the surface of the ground, and the whole plant but 2½ inches in height.

91. (619.) C. STRIGOSUS L. Straw-colored Cyperus.
Borders of ditches and marshes; common. August 1.

46. KYLLINGA Rottb.

92. (623.) K PUMILA Michx. Kyllingia.
Low, sandy waste or cultivated ground; frequent.

A handsome little sedge, the flowering heads with a pleasing fragrance

47. DULICHIUM L. C. Richard.

93. (624.) D. ARUNDINACEUM (L.) Britton. Dulichium.
(*D. spathaceum* Pers.)
Borders of marshes and ditches; frequent. July 20.

48. ELEOCHARIS R. Br.

94. (625) E. ACICULARIS (L.) R. & S. Needle Spike-rush.
Low muddy places about ponds; scarce.
Five Mile Pond. May 22, 1889.

95. (638.) E. OVATA (Roth.) R. & S. Ovoid Spike-rush.
Margins of ponds and ditches in shallow water; common. May 22

96. (645.) E. TENUIS (Willd.) Schultes. Slender Spike rush.
Moist banks, prairies and ditches; frequent. May 25.

49. FIMBRISTYLIS Vahl.

97. (654.) F. AUTUMNALIS (L.) R. & S. Slender Fimbristylis.
Low sandy soil; frequent. Aug. 10.

50. STENOPHYLLUS Raf.

98. (659.) S. CAPILLARIS (L.) Britton. Hair-like Stenophyllus.
(*Fimbristylis capillaris* Gray.)
Sandy banks and borders of fields; scarce.
Heckland. T. H. & L railway above Otter Creek Juction.

Grows in dense circular tufts; the hair-like stems rarely a foot in height. July 18.

51. SCIRPUS L.

99. (660.) S. AMERICANUS Pers. Bulrush.
(*S. pungens* Vahl.)
Borders of ponds and large ditches; frequent. July 5.

100. (662.) S. ATROVIRENS Muhl. Dark Green Bulrush.
Low, wet meadows and prairies; frequent. May 25.

101. (667.) S. CYPERINUS (L.) Kunth. Wool Grass.
(*Eriphorum cyperinum* L.).
Bogs and margins of ponds; scarce.
Old canal bed below Spring Hill. Marsh north of Van. railway near Beach's.

102. (672.) S. FLUVIATILIS (Torr.) A. Gray. River Club-rush.
Margins of Five-Mile Pond and Wabash River, near Durkey's Ferry; frequent locally.
The culm sometimes seven feet high. July 10.

103. (674.) S. LACUSTRIS L. Great Bulrush.
Margins of ponds and streams; abundant at Five-Mile and Goose Ponds, and sparingly at Coal Creek. June 5.

52. ERIOPHORUM L.

104. (697.) E. VIRGINICUM L. Cotton Grass.
Scarce; marshy margin of Five-Mile Pond. September 21, 1887.

53. CAREX* L.

105. (754.) C. ASA-GRAYI Bailey. Gray's Sedge.
(*C. grayii* Carey.)
Borders of ditches in shaded places; scarce. May 5.

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* A careful search will probably reveal as many more species of this genus as I have listed. No especial search was made for them, and such species only were taken as came conveniently to hand while collecting other plants for my classes in botany.

106. (773.) C. CEPHALOPHORA Muhl. Oval-headed Sedge.
Fence rows and open woods; frequent. May 16.

107. (777.) C. CONJUNCTA Boott. Soft Fox Sedge.
Taken but once; from the swampy woods at Heckland. June 5.

108. (780.) C. CRINITA Lam. Fringed Sedge.
Marshes and sides of ditches; frequent. May 20.

109. (831) C. GRANULARIS Muhl. Meadow Sedge.
Borders of moist prairies; scarce.
Heckland. May 17.

110 (851.) C. LAXIFLORA Lam. Loose flowered Sedge.
Open woods and borders of fields; common. May 11.

111. (865.) C. LUPULINA Muhl. Hop Sedge.
Low, wet woods and bogs; frequent. May 25.

111a. (867.) C. LUPULINA GIGANTEA (Rudge) Britton.
(*C. lupulina pedunculata* Dewey.)
Ditches and borders of marshes; frequent. May 10.

112. (870.) C. LURIDA Wahl. Sallow Sedge.
Wet meadows; common. May 5.

113. (927.) C. ROSEA Schk. Stellate Sedge.
Rich, moist hillsides; frequent. May 1.

114. (938) C. SCOPARIA Schk. Pointed Broom Sedge.
Low, wet places; frequent. June 3.

115. (940.) C. SHORTIANA Dewey. Short's Sedge.
Scarce; ditch by side of Van. Railway near Glen. May 15.

116. (943.) C. SPARGANIOIDES Muhl. Bur reed Sedge.
Marshes and low, open woods; frequent. May 22.

117. (944.) C. SQUARROSA L. Rough Sedge.
Low, wet meadows and ditches; frequent. May 25.

118. (950.) C. STIPATA Muhl. Awl-fruited Sedge.
Low, wet ground; common. May 17.

119. (951.) C. STRAMINEA Willd. Straw Sedge.
Open woods, thickets and fence rows; common. May 19.

120. (979.) C. TRIBULOIDES Wahl. Blunt Broom Sedge.
Ditches along the railways; scarce. May 21.

121. (1003.) C. VULPINOIDEA Michx. Fox Sedge.
Low, grassy places; common. May 25.

ARACEÆ. Arum Family.

54. ACORUS L.

122. (1010.) A. CALAMUS L. Sweet Flag. Calamus.
Marshes and wet places along streams; scarce. May 28.
Glen. Grant. East of Sand Hill.

55. PELTANDRA Raf.

123.* (1015.) P. VIRGINICA (L.) Kunth. Arrow Arum.
(*P. undulata* Raf.)
Large ditches and margins of ponds; scarce. June 9.
Heekland. Goose Pond.

54. ARISÆMA Mart.

124. (1016.) A. DRACONTIUM (L.) Schott. Green Dragon. Dragon Root.
Open woods in moist, rich soil; scarce. May 12.
Sand Hill. S. E. of Hunt's. Ferrell's.

125. (1017.) A. TRIPHYLLUM (L.) Torr. Indian Turnip. Jack-in-the-Pulpit.
Open woods, ravines, etc.; common. April 14.

LEMNACEÆ. Duckweed Family.

57. SPIRODELA Schleid.

126. (1018.) S. POLYRHIZA (L.) Schleid. Duck's Meat. Duckweed.
Ponds and slow-flowing ditches; common.

58. LEMNA L.

127. (1020.) L. MINOR L. Lesser Duckweed.
Ponds and ditches; frequent. May 31, 1890.

This species and *S. polyrhiza* L. often cover thickly the entire surface of the smaller ponds in the county.

128. (1022.) L. TRISULCA L. Star Duckweed.
Ponds; scarce. May 31, 1890.
Goose Pond.

59. WOLFFIA Horkel.

129. (1025.) W. COLUMBIANA Karst. Columbia Wolffia.
Abundant in Goose Pond in 1890–91. Not noted elsewhere.

COMMELINACEÆ. Spiderwort Family.

60. COMMELINA L.

130. (1043.) C. VIRGINICA L. Day Flower.
Sandy banks; scarce. June 17.
Old canal and hillside near Five-Mile Pond.

61. TRADESCANTIA L.

131. (1045.) T. PILOSA J. G. C. Lehm. Zig-zag Spiderwort.
(*T. virginica flexuosa* Watson.)
Dry, gravelly banks, especially along railways; frequent. June 5.

The stems of this species are shorter and much more hairy than those of *T. virginiana* L. They are often branched, zigzag above, and bear a close cluster of small blue flowers in each of the upper axils.

132. (1047.) T. VIRGINIANA L. Common Spiderwort.
Rich, moist banks and hillsides; frequent. May 22.

PONTEDERIACEÆ. Pickerel weed Family.

62. PONTEDERIA L.

133.* (1048.) P. CORDATA L. Pickerel-weed.
Shallow water near margins of ponds; scarce. July 18.
Goose Pond. Five-Mile Pond.

63. HETERANTHERA R. and P.

(*Schollera* Schreb.)

134. (1050.) H. DUBIA (Jacq.) Morong. Water Star-grass.
(*H. graminea* Vahl.)
Noted but once, Sept. 25, 1887, near the borders of an island in the Wabash River, where it was frequent.

JUNCACEÆ. Rush Family.

64. JUNCUS* L.

135. (1053.) J. ACUMINATUS Michx. Sharp-fruited Rush.
Low, wet grounds; frequent. May 22.

135a. (1054.) J. ACUMINATUS DEBILIS (A. Gray) Engelm.
Sandy margins of ponds; common. May 20.

136. (1070.) J. EFFUSUS L. Common or Soft Rush.
Low muddy places; common. May 25.

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* The species of this genus have not been carefully collected and a number of additional forms doubtless occur in the county.

137. (1075.) J. MARGINATUS Rostk. Grass-leaved Rush.
Ditches; scarce. May 28.
Side of Van. railway, near Glen.

138. (1090.) J. TENUIS Willd. Wiry-stemmed Rush.
Borders of damp fields, ditches, etc.; common. June 6.

65. JUNCOIDES Adans.

(*Luzula* DC.)

139. (1101.) J. CAMPESTRE (L.) Kuntze. Wood Rush.
(*L. campestris* DC.)
Open woods and fence rows; common. April 20.

LILIACEÆ. Lily Family.

66. VERATRUM L.

140. (1120.) V. WOODII Robb. Wood's False Hellebore.
High, dry hills; scarce. July 5.
Coal Creek.

Occurs in Indiana as far north as Tippecanoe County. The root leaves are in a single, compact bunch, and are large and prominent in May and June.

67. UVULARIA L.

141. (1121.) U. GRANDIFLORA J. E. Smith. Large-flowered Bellwort.
Sides of ravines and wooded slopes; scarce. April 14.
Honey Creek. Grant. Coal Creek.

68. HEMEROCALLIS L.

142. (1126.) H. FULVA L. Common Day Lily.
Roadsides and banks of railways, escaped; scarce. June 2.

69. ALLIUM L.

143. (1128.) A. CANADENSE L. Wild Garlic.
(*A canadense* Kalm.)
Moist meadows and open woods; scarce.
Heckland. South of Van. Railway, opposite Beach's. May 25.

144. (1129) A. CERNUUM Roth. Wild Onion.
Sides of ravines and gravelly banks; rare.
Glen. May 28, 1887. (*Evermann.*)

145. (1135.) A. TRICOCCUM Ait. Wild Leek.
Rich, moist hillsides; rare.
Coal Creek. June 6, 1893.

70. NOTHOSCORDUM Kunth.

146.* (1137. N. ORNITHOGALOIDES (Walt.) Kunth. Yellow Fal Garlic.

(*N. striatum* Kunth.)

Sandy hillsides and gravelly banks; scarce.

Hillside east of Five-Mile Pond; Lost Creek near Seventh Street bridge.

71. LILIUM L.

147.* (1139.) L. CANADENSE L. Wild Yellow Lily.

Moist banks; rare.

Van. railway near Glen. June 29.

148. (1143.) L. PHILADELPHICUM L. Wild Orange-red Lily.

Prairies and sandy banks; rare.

Heckland. June 14.

72. ERYTHRONIUM L.

149.* (1147.) E. ALBIDUM Nutt. White Dog's-tooth Violet.

Low open woods and clearings; frequent. April 13.

150. (1148.) E. AMERICANUM Ker. Yellow Adder's Tongue. Dog's-tooth Violet.

Open woods, in rich, rather moist soil; common. April 1.

73. CAMASSIA Lindl.

151. (1152.) C. FRASERI (A. Gray) Torr. Eastern Quamash. Wild Hyacinth.

Banks and hillside thickets; scarce.

Lost Creek, near Seventh Street bridge. Hillside, near Ft. Harrison. May 8.

74. ORNITHOGALUM L.

152. (1154.) O. UMBELLATUM L. Star-of-Bethlehem.

Escaped, sparingly.

Hillside west of Beach's. May 3.

75. ASPARAGUS L.

153. (1160.) A. OFFICINALIS L. Garden Asparagus.

Sandy banks, roadsides and borders of fields, escaped; frequent, especially along the old canal. May 10.

76. VAGNERA Adans.

(*Smilacina* Desf.)

154. (1164.) V. RACEMOSA (L.) Morong. False Solomon's Seal. False Spikenard.

(*S. racemosa* Desf.)

Moist, shaded banks and woods; frequent. May 11.

77. POLYGONATUM Adans.

155. (1172.) P. BIFLORUM (Walt.) Ell. Smaller Solomon's Seal.
Open woods and fence rows; frequent. May 11.

155a. (1173.) P. BIFLORUM COMMUTATUM (R. & S.) Morong. Great Solomon's Seal.

(*P. giganteum* Dietr.)

Shaded banks and damp hillside thickets; frequent. May 21.

78. TRILLIUM L.

156. (1176.) T. CERNUUM L. Nodding Trillium.
Moist hillside thickets; scarce. April 27.
Coal Creek. Grant.

157. (1177.) T. ERECTUM L. Birth Root. Bath Flower.
Sides of ravines in rich, shaded soil; scarce.
Southeast of Hunt's. Honey Creek. April 27.

All specimens taken were the white flowered form with long declined peduncle, (*T. erectum declinatum* Gray's Man., 5th ed.). Specimens with leaves measuring 7x6½ inches, and peduncles 4½ inches in length have been noted.

158. (1180.) T. RECURVATUM Beck. Recurved Purple Trillium.
Moist, rich woods; common. April 10.

159. (1181.) T. SESSILE L. Sessile Trillium.
Open, rich woods; common. April 8.
The leaves rarely six, in two whorls.

79. ALETRIS L.

160. (1182b.) A. FARINOSA L. Aletris. Colic-root. Star-grass. Unicorn.
Prairies, in dry or sandy soil; scarce. June 3.
Heckland.

SMILACEÆ. Smilax Family.

80. SMILAX L.

161. (1185.) S. GLAUCA Walt. Glaucous-leaved Green-brier.
Thickets in dry, sandy soil; scarce. May 22.
Canal bank north of Ft. Harrison.

162. (1186.) S. HERBACEA L. Carrion Flower.
Thickets and fence rows in moist soil; frequent. May 20.

The vile-smelling flowers in globular, umbel-like heads. Gray's Manual states that these heads contain twenty to forty flowers, but a head of fruit collected in October, 1896, was seven and one-half inches in circumference and contained 251 berries.

163. (1187.) S. HISPIDA Muhl. Hispid Green-brier.
Rich, open woods in sandy soil, climbing twenty-five or more feet over shrubs or low trees; frequent. May 21.

This species has larger leaves (the blade of a specimen at hand being six and one-half inches long by five and three-quarters wide) and climbs higher than any other in the county. It is but little, if any, branched. The spines are of two sizes, the larger and fewer ones about two-thirds of an inch long and scattered irregularly the full length of the stem, but more common on its basal half. The small black ones are very numerous on the lower five or six feet of a mature stem, but are seldom found higher up.

164. (1190.) S. PSEUDO CHINA L. Long-stalked Green-brier.
Sandy, hillside thickets; scarce. May 21.
Thicket near Five-Mile Pond. (*Evermann.*)

165. (1191.) S. ROTUNDIFOLIA L. Common Green-brier. Sheep-brier.
Moist woods and borders of thickets; common. May 11.

165a. (——) S. ROTUNDIFOLIA QUADRANGULARIS Gray. Four-angled Green-brier.
Dryer soil; frequent. June 3.

AMARYLLIDACEÆ. Amaryllis Family.

81. HYPOXIS L.

166.* (1199.) H. HIRSUTA (L.) Coville. Star-grass.
(*H. erecta* L.)
Open, sandy woods; scarce. May 7.
Five-Mile Pond. Heckland.

DIOSCOREACEÆ. Yam Family.

82. DIOSCOREA L.

167. (1200a.) D. VILLOSA L. Wild Yam.
Borders of thickets and fence rows; scarce.
Beach's. Ferrell's.

The three-celled broadly winged pods are quite ornamental in autumn.

IRIDACEÆ. Iris Family.

83. IRIS L.

168. (1212.) I. VERSICOLOR L. Larger Blue Flag.
Low, wet places; frequent. May 10.

84. GEMMINGIA Fabr.

(*Belamcanda* Adans.)

169. (1214.) G. CHINENSIS (L.) Kuntze. Blackberry Lily.
(*B. chinensis* Adans.)
Roadsides, escaped; scarce.
Two miles south of Atherton. (*Scovell.*)

85. SISYRINCHIUM L.

170. (1215.) S. BERMUDIANA L. Blue-eyed Grass.
(*S. angustifolium* Mill.)
Moist, grassy places; common.

The form known as *S. anceps* Cav. is frequent at Heckland along the borders of moist prairies.

ORCHIDACEÆ. Orchis Family.

86. CYPREPEDIUM L.

171.* (1221.) C. HIRSUTUM Mill. Larger Yellow Lady's Slipper. Moccasin Flower.
(*C. pubescens* Willd.)
Rich, dry woods; scarce.
Heckland. Coal Creek. May 16.

87. ORCHIS L.

172. (1225.) O. SPECTABILIS L. Showy Orchis.
Open, rich woods; frequent.
Opposite St. Mary's; Sand Hill, etc. April 23.

88. HABENARIA Willd.

173. (1228.) H. BRACTEATA (Willd.) R. Br. Bracted Green Orchis.
Wooded hillsides; rare.
Coal Creek. May 18, 1893.

Three specimens found, no one of which was more than eight-flowered.

174. (1233.) H. FLAVA (L.) A. Gray. Greenish Orchis.
(*H. virescens* Spreng.)
Damp, dense woods; rare.
Heckland. June 10, 1891.

Recorded before only from Noble County.

89. GYROSTACHYS Pers.

(*Spiranthes* Richard.)

175. (1252.) G. CERNUA (L.) Kuntze. Ladies' Tresses. Screw Stem.
(*S. cernua* Richard.)
Margins of moist meadows and ponds; scarce.
Goose Pond. Heckland. September 4.

90. PERAMIUM Salisb.

(*Goodyera* R. Br.)

176. (1263.)* P. PUBESCENS (Willd.) C. C. Curtiss. Rattlesnake Plantain.
(*G. pubescens* R. Br.)
High, dry hills; rare.
Coal Creek. September 18, 1892. In fruit.

Readily known by its handsome, white-reticulated root-leaves.

91. ACHROANTHES Raf.

(*Microstylis* Nutt.)

177. (1266.) A. UNIFOLIA (Michx.) Raf. Adder's Tongue Orchis.
(*M. ophioglossoides* Nutt.)
High, dry hills; rare.

A single specimen was taken at Coal Creek, September 28, 1893. In Monroe County a number of specimens were secured from high hills, where they were found in company with *Medeola virginiana* L., *Pogonia verticillata* Nutt., and in the midst of clumps of the moss *Polytrichum commune* L. Specimens taken by the writer in Arkansas were also found on high hills, though the habitat given in Gray's Manual is "low, moist ground." The Monroe County plants were recorded in Proc. Ind. Acad. Sci., 1895, 198.

92. LEPTORCHIS Du Petit Thouars.

(*Liparis* Richard)

178. (1267.) L. LILIIFOLIA (L.) Kuntze. Tway-blade.
(*Liparis liliifolia* Richard.)
Rich, open woods; rare.
Taken but once, southeast of Hunt's Rosary. June 11, 1888.

93. APLECTRUM Nutt.

179. (1278.) A. SPICATUM (Walt.) B. S. P. Putty-root. Adam and Eve.
(*A. hiemale* Nutt.)
Rich, sandy soil in open woods; frequent. May 8.

This is by far the most common orchid found in the county, having been noted in a dozen or more localities—Sand Hill, Beach's, Coal Creek, etc. The corms are eaten raw by some people, and their mucilaginous center is said to be a good cement for porcelain-ware, etc.

DICOTYLEDONES.

SAURURACEÆ. Lizard's Tail Family.

94. SAURURUS L.

180.* (1279.) S. CERNUUS L. Lizard's Tail.
Ditches and borders of ponds; frequent. June 12.
Conover's Pond. Van. railway near Beach's. Heckland.

JUGLANDACEÆ. Walnut Family.

95. JUGLANS L.

181. (1280.) J. CINEREA L. Butternut. White Walnut.
Sides of ravines and open upland or river terrace woods in rich soil; frequent. April 20.

The fruit sometimes double.

182. (1281.) J. NIGRA L. Black Walnut.
Rich, open woods; frequent. April 15.

All the larger trees have long since been sawed into lumber, and a specimen two feet in diameter is now seldom seen.

96. HICORIA Raf.

(*Carya* Nutt.)

183. (1282) H. ALBA (L.) Britton. Mocker-nut. White-heart Hickory.
C. tomentosa (Nutt.)

Wooded slopes and open upland woods; frequent.

Nut smaller than that of *H. sulcata*, which it most closely resembles; often attenuate above; shell very hard; kernel less sweet; husk thinner, not parted to the base.

184. (1283.) H. GLABRA (Mill.) Britton. Pignut. Broom Hickory. Black Hickory.
(*C. porcina* Nutt.)

Dry Hills and uplands; frequent.

The wood excels for making axe-handles.

185. (1285.) H. MINIMA (Marsh.) Britton. Bitter-nut. Swamp Hickory.
(*C. amara* Nutt.)

Moist, open woods and borders of swamps; frequent.

Nut more rounded, shell thinner, and kernel much more bitter than in *H. glabra*.

186. (1286.) H. OVATA (Mill.) Britton. Shell or Shag-bark Hickory.
(*C. alba* Nutt.)

Open woods and sloping hillsides in rich soil; common. April 18.

187. (1287.) H. PECAN (Marsh.) Britton. Pecan Nut.
(*C. olivaeformis* Nutt.)

Rich bottom lands; scarce.

Several trees grow in the river bottoms north of Ft. Harrison.

188. (1288.) H. SULCATA (Willd.) Britton. Big Shell-bark. King-nut. Big-nut Hickory.
(*C. sulcata* Nutt.)

Moist, rich, usually alluvial soil; scarce. April 23.

McKeen's woods. Woods near Goose Pond. River bottoms north of Ft. Harrison.

Bark less shaggy than in *H. ovata*. Nut large, a little longer than broad; mucronate at both ends; kernel sweet; husk very thick, completely separating into four pieces.

SALICACEÆ. Willow Family.

97. POPULUS L.

189.* (1299.) P. HETEROPHYLLA L. Downy Poplar.

Noted only around the borders of the Goose Pond, where it is common.

Probably its most northern record. May 10.

190. (1300.) P. MONILIFERA Ait. Cottonwood. Necklace Poplar.
Borders of streams and low alluvial soil; common. April 5.

Specimens along the Wabash reach a height of 130 feet. The wood is too light and soft to be of great commercial value, but is much used for paper pulp, packing cases, matched ceiling, etc.

191. (1302.) P. TREMULOIDES Michx. American Aspen. Quaking Asp.
Dry hillside woods and clearings; scarce.
Heckland. Coal Creek. April 5.

All trees noted were of small size.

98. SALIX L.

192. (1304.) S. ALBA L. White Willow.
Old fields near dwellings; scarce.

South of the Seventh Street bridge across Honey Creek is an example measuring thirteen feet and eight inches in circumference.

193. (1316.) S. CORDATA Muhl. Heart-leaved Willow.
Low, moist places; common. April 20.

Shrubs three to fifteen feet high, the stipules reniform, toothed, conspicuous.

194. (1320.) S. DISCOLOR Muhl. Glaucous Willow. Pussy Willow.
Low, wet banks and borders of prairie swamps; frequent. April 5.

Grows in dense clumps and is the first willow to bloom in spring.

195. (1330.) S. HUMILIS Marsh. Prairie Willow.
Noted only in the raw prairie at Heckland, where it is common. April 20.

A shrub, two to six feet high; usually two or three together.

196. (1331.) S. LONGIFOLIA Muhl. Long-leaved Willow. Sand-bar Willow.
Sandy, moist places along the Wabash river and the larger ponds; frequent. April 20.

197. (1335.) S. NIGRA Marsh. Black Willow.
Banks of streams and ponds; common. May 10.

This is the largest native willow found in the county, in some instances reaching a diameter of nearly two feet. Along the low banks of the smaller streams it often grows in great masses. The roots often extend in search of moisture to a depth of ten feet or more into the alluvial soil in which the species usually grows.

197a. (1336.) S. **NIGRA FALCATA** Torr. Scythe leaved Black Willow.
With the type, but less frequent.

198. (1338.) S. **PETIOLARIS** Smith. Petioled Willow.
Low, moist, sandy banks; scarce. April 15.
Bottoms along Old Canal from Ft. Harrison to Five-Mile Pond; Heckland.

BETULACEÆ. Birch Family.

99. CARPINUS L.

199. (1349.) C. **CAROLINIANA** Walt. Water Beech. Horn-beam.
Borders of streams and swamps; frequent.

The wood of both this and the next species is very heavy, strong and durable, and fitted for posts, levers, handles of tools, etc.

100. OSTRYA Scop.

200. (1350.) O. **VIRGINIANA** (Mill.) Willd. Hop-Hornbeam. Iron Wood. Lever Wood. Deer Wood.
Dry woods and sides of ravines; frequent.

101. CORYLUS L.

201. (1351.) C. **AMERICANA** Walt. Wild Hazle-nut.
Borders of woods and clearings in dry soil; frequent. March 16.

102. BETULA.

202. (1356.) B. **NIGRA** L. River Birch. Red Birch.
Banks of streams; common along Honey Creek and its tributaries. April 25.

Noted also by the writer in Putnam County along the tributaries of Eel River, and in Marion County, northwest of Indianapolis, along White River.

FAGACEÆ. Beech Family.

103. FAGUS L.

203. (1367.) F. **ATROPUNICEA** (Marsh.) Sudw. American Beech.
(*F. ferruginea* Ait.)
Upland, usually flat, damp woods in clayey soil; common. April 16.

Many of the farmers and woodmen of Vigo County recognize two species of beech—the one, "Red Beech," growing in dry soil, a rather small, scraggy tree, which retains its leaves through most of the winter, and the wood of which is almost uncleavable on account of its curly or twisted fibres; the other, the "White Beech," the large, straight boled tree, growing in moist soil, the leaves deciduous in autumn, the wood easily split, and having a high value for fuel and the making of chairs, shoe-lasts and tool handles.

104. QUERCUS L.

204.* (1370.) Q. ALBA L. White Oak.

Open, upland woods; usually in dry, rather poor soil; common.

One of the most valuable of the forest trees yet remaining in any numbers. The largest specimens have been removed, but many of medium size are still to be found in the eastern half of the county. Within the last two decades the lumber of this species has been put to many uses for which it was spurned when walnut, "yellow poplar" and other trees were abundant. As a consequence, the value of white oak trees has slowly but surely enhanced, and the farmer has often received more for them than the land on which they grew was worth.

205. (1375.) Q. COCCINEA Wang. Scarlet Oak.

Sandy hillsides and river terrace woods; frequent.

Spring Hill; near Five-Mile Pond, etc.

Known by its grayish, rather smooth bark; its shining, *narrow*-lobed leaves, which turn bright red in autumn, and its medium-sized, white-meated acorn, half covered with a top-shaped cup.

This species is seldom distinguished by the land-owner from the red oak (*Q. rubra* L.). Its wood is similar in structure, and the uses to which it is put are practically the same.

206. (1381.) Q. IMBRICARIA Michx. Shingle Oak. Laurel Oak. Peach-leaved Oak.

Wooded slopes in loose, sandy soil; common.

Distinguished by its shining, lanceolate entire leaves, resembling in general appearance those of the peach. They often remain on the tree throughout the winter, and when old have the lower surface thickly covered with yellowish down. The acorn is short and broad, with the cup covering its lower third. Among the farmers of Vigo County this species is most commonly known as the "Jack Oak," a name which more rightfully belongs to *Quercus nigra* L. The wood is coarse-grained, heavy and hard, but is seldom used except for fuel, for which it is highly esteemed; and for clapboards.

207. (1385.) Q. MACROCARPA Michx. Bur Oak. Over Cup or Mossy Cup Oak.

Open woods, especially those of the river terrace; common. May 15.

Readily known by its thick, rough, shaggy bark; its many long branches, the lowermost ones on the larger trees usually within ten feet of the ground; its large obovate leaves and large acorn with the cup margined with a moss-like fringe. The lumber is close-grained, hard and durable and valuable for many purposes.

208. (1388.) Q. MINOR (Marsh.) Sarg. Post Oak. Iron Oak.
(*Q. stellata* Wang.)

Dry, sandy soil; scarce.

Hillside near Spring Hill. Roadside one mile north of Goose Pond. May 20.

A small oak with close gray bark; the leaves thick, with broad rounded lobes, covered beneath with rusty down. Acorns very small.

209.* (1389.) Q. MUHLENBERGII Engelm. Yellow Oak. Chinquapin Oak. False Chestnut Oak.

Upland wooded slopes and river terrace woods in rich, loose soil; common.

In Vigo County two marked varieties of this tree occur: In the one the leaves closely resemble those of the common chestnut, being lanceolate, acuminate, 5½ inches long by 1¾ inches wide (average), sharply serrate, the veins very prominent; in the other the leaves are broadly ovate or obovate, 7 inches long by 5 wide, the teeth rounded, the veins less prominent. The bark of each closely resembles that of the white oak, and the acorns of both are rather small, sweet and edible. No connecting forms are seen, and I would consider the two distinct, but Dr. J. M. Coulter, to whom specimens were sent, writes that they are considered varieties of one species by Dr. Engleman and other authorities who have made a special study of the oaks.

210. (1393.) Q. PALUSTRIS DuRoi. Swamp Spanish Oak. Pin Oak.

Borders of swamps and low, wet woods; frequent.

Known by its very smooth, dark-gray bark; its narrow-lobed, glossy leaves; its *small* acorn with very shallow, saucer-shaped cup. The lower limbs of this oak are also almost invariably decurved and at a little distance appear thorny on account of the many short shoots, or secondary branches which they bear. The tree is seldom large enough to be profitably worked, and is little used, except for clapboards and staves.

211. (1396.) Q. PLATANOIDES (Lam.) Sudw. Swamp White Oak.
(*Q. bicolor* Willd.)

Swampy places in upland or river terrace woods; scarce.

Deming's woods on Poplar Street road. Section 33, Honey Creek Township, etc. May 15.

The bark resembles that of the white oak (*Q. alba* L.), but the leaves are much larger, obovate, with a wedge-shaped base, and, when old, white-hoary beneath. The acorns are somewhat shorter, but of greater diameter, and more pointed than those of the white oak.

212. (1399.) Q. RUBRA L. Red Oak.

Dry hillsides and flat upland woods; common.

Known by its smoothish, dark-gray bark; its large, thin leaves, the lobes of which are acuminate and broad at base, and the large acorn, one inch long, with short, flat cup. The leaves turn a dull brownish red after frost. The wood is reddish, coarse-grained and inferior in value, being used mainly for clapboards, staves, and cheap grades of furniture.

213. (1401.) Q. VELUTINA Lam. Black Oak. Quercitron. Yellow-barked Oak.

(*Q. coccinea var. tinctoria* Bartram.)

Moist or dry upland soil; frequent.

Distinguished from the scarlet oak (*Q. coccinea* Wang.), which it most closely resembles, by its black or dark-brown, deeply furrowed outer bark, which is rich in tannin; its orange-colored, very bitter inner bark, which yields *quercitron*, a valuable yellow dye; its much broader-lobed, less shining leaves, which turn yellow or dark red in autumn, and by its somewhat shorter, less pointed, yellowish-meated acorn. The wood is reddish and coarse-grained, stronger and more durable than that of either the red or scarlet oak.

ULMACEÆ. Elm Family.

105. ULMUS L.

214. (1403.) U. ALATA Michx. Winged Elm.

One or two specimens grow near the I. & St. L. trestle west of Wabash River. Frequent in Crawford and Harrison counties.

215. (1404.) U. AMERICANA L. White Elm. American Elm.

Low, open woods; common. April 12.

The American or White Elm is one of the most handsome native forest trees. It will grow in any soil, but reaches its greatest development in low, rich woods and along small streams. It branches widely, and in cities possessing broad streets it is well suited for shade purposes. Where properly set out and tended, streets planted with it become in time columned and arched like the aisles of a Gothic cathedral.

Its one great disadvantage, however, is its liability to injury from insects. In this country over 80 species prey upon it. The elm tree borer, numerous varieties of caterpillars, and a plant louse which disfigures the leaves by crumpling and distorting them, are its most abundant enemies in Indiana; while in the eastern States, and rapidly traveling westward, is the "Imported Elm Leaf Beetle," which literally strips the tree of its foliage.

216. (1405.) U. PUBESCENS Walt. Slippery Elm. Red Elm.

(*U. fulva* Michx.)

Rich woods and sides of ravines; frequent. March 29.

106. CELTIS L.

217. (1408.) C. OCCIDENTALIS L. Hackberry. Sugarberry.
Open woods, especially those of river terrace; frequent. April 14.

MORACEÆ. Mulberry Family.

107. MORUS L.

218. (1412.) M. RUBRA L. Red Mulberry.
Open, rich woods and borders of old fields; frequent. May 1.

Leaves have been measured which were eight inches broad and 10½ inches long. In Vigo County the fruit ripens about June 15.

108. TOXYLON Raf.

(*Maclura* Nutt.)

219. (1413.) T. POMIFERUM Raf. Osage Orange.
(*M. aurantica* Nutt.)
Escaped, sparingly.
Banks of Sugar Creek below National Road bridge. Roadside near St. Mary's.

109. HUMULUS L.

220. (1414.) H. LUPULUS L. Common Hop.
Noted along Lost Creek and banks of Van. Railway near Glen; scarce. May 25.

110. CANNABIS L.

221. (1415.) C. SATIVA L. Hemp.
Waste, sandy places; frequent. July 12.

Sometimes grows to a height of 12 feet.

URTICACEÆ. Nettle Family.

111. URTICA L.

222. (1418.) U. GRACILIS Ait. Tall Nettle.
Fence rows and borders of woods in moist, rich soil; frequent. June 13.

112. URTICASTRUM Fabric.

(*Laportea* Gaud.)

223. (1420.) U. DIVARICATUM (L.) Kuntze. Wood Nettle.
(*L. canadensis* Gaud.)
Low moist woods and sides of ravines; scarce. July 1.
Coal Creek. Woods south of Van. Railway, near Beach's.

113. ADICEA Raf.

(*Pilea* Lindl.)

224. (1421.) A. PUMILA (L.) Raf. Clearweed. Richweed.
(*P. pumila* Gray.)
Bottoms of ravines and moist, shaded places; frequent. June 10.

114. BOEHMERIA Jacq.

225. (1422.) B. CYLINDRICA (L.) Willd. False Nettle.
Low, moist woods and borders of swamps; frequent. June 16.

SANTALACEÆ. Sandal-wood Family.

115. COMANDRA Nutt.

226. (1429.) C. UMBELLATA (L.) Nutt. Bastard Toad-flax.
Dry virgin prairies; scarce. May 7.
Heckland.

ARISTOLOCHIACEÆ. Birthwort Family.

116. ASARUM L.

227.* (1432.) A. CANADENSE L. Wild Ginger.
Sides of ravines and rich wooded slopes; frequent. April 17.
Honey Creek; southeast of Hunt's; Coal Creek, etc.

POLYGONACEÆ. Buckwheat Family.

117. RUMEX L.

228. (1454.) R. ACETOSELLA L Field Sorrel. Sheep Sorrel.
Barren or poor soil, roadsides, old fields, etc.; abundant. May 11.

229.* (1455) R. ALTISSIMUS Wood. Pale Dock. Peach-leaved Dock.
Borders of ponds, ditches, and moist banks; common. May 4.

230. (1458.) R. CRISPUS L. Curled Dock.
Rich, waste soil; abundant. May 25.

231. (1460.) R. OBTUSIFOLIUS. Bitter Dock.
Roadsides and waste places; common. June 11.

232. (1468.) R. VERTICILLATUS L. Swamp Dock.
Swamps and borders of marshes; frequent. June 14.
Margins of Goose and Five-Mile ponds. Heckland.

118. POLYGONUM L.

233.* (1470.) P. AMPHIBIUM L. Water Persicaria.
Shallow water near margins of ponds; common. July 7.

This species, and *P. pennsylvanica* L., cover acres of the margins of the larger ponds of Vigo County. The flowers of both are more showy than those of any other of our native species; the spikes of *P. amphibium* often paired.

234.* (1471.) P. ARIFOLIUM L. Halberd-leaved Tear Thumb.
Ravines and borders of small streams; scarce.

Along Lost Creek, south side of Van. Railway, and one of its tributaries east of Highland Lawn. Found also near Michigan City, Lake County.

235. (1472.) P. AVICULARE L. Knot Weed. Doorweed. Goose Grass.
Yards, roadsides, etc.; abundant. June 1.

236. (1477.) P. CONVOLVULUS L. Black Bindweed.
Borders of cultivated fields and fence rows; frequent, June 10.

237. (1482.) P. EMERSUM (Michx.) Britton.
(*P. muhlenbergii* Watson.)
Sandy margins of ponds and marshes; frequent. June 10.
Conover's and Five-Mile ponds. Marsh south of Fair Ground.

238. (1483.) P. ERECTUM L. Erect Knot Grass.
Damp, waste soil; common. June 27.

239.* (1486.) P. HYDROPIPER L. Common Smartweed. Water Pepper.
Ditches and borders of ponds; common. July 11.

240.* (1487.) P. HYDROPIPEROIDES Michx. Mild Water Pepper.
Shallow water and muddy margins of ponds; common. July 18.

241.* (1493.) P. PENNSYLVANICUM L. Pennsylvania Knotweed. Glandular Knotweed.
Ditches and borders of ponds; common. July 12.

242.* (1499.) P. PERSICARIA L. Lady's Thumb. Heartweed.
Low wet soil; common. June 8.

243.* (1500.) P. PUNCTATUM Ell. Water Smartweed.
(*P. acre* HBK.)
Swamps and low ground along the river; common. July 14.

244.* (1502.) P. RAMOSISSIMUM Michx.
Low, sandy grounds; scarce. July 11.
Borders of woods near marsh, south of Fair Ground.

The first record for the State.

245.* (1504.) P. SAGITTATUM L. Arrow-leaved Tear-thumb.
Low, wet places, especially about borders of upland thickets where it often climbs six to eight feet high over shrubs and tall grass; common. August 2.

246. (1505.) P. SCANDENS L. Climbing False Buckwheat.
(*P. dumetorum scandens* Gray.)
Moist, open woods, fence rows, etc.; abundant. July 18.

Sometimes twines 20 or more feet high over the sides of a honey locust or other much-branched tree.

247. (1507.) P. TENUE Michx.
Rich, dry soil; scarce. August 1.
Borders of McKeen's woods. Beach's.

248.* (1508.) P. VIRGINIANUM L. Virginia Smartweed.
Dense woods in moist, rich soil; common. July 20.

119. FAGOPYRUM Gaertn.

249. (1510.) F. FAGOPYRUM (L) Karst. Buckwheat.
(*F. esculentum* Moench.)
Borders of old fields and along railways; scarce. May 25.
Heckland.

CHENOPODIACEÆ. Goosefoot Family.

120. CHENOPODIUM L.

250. (1515.) C. ALBUM L. Lamb's-Quarters. Pigweed.
Waste or cultivated grounds; very common. July 6.

251. (1517.) C. AMBROSIOIDES L. Mexican Tea.
Streets and alleys of Terre Haute; common. July 2.

252. (1518.) C. ANTHELMINTICUM L. Wormseed.
(*C. ambrosioides anthelminticum* Gray.)
With the preceding; less frequent. July 28.

253. (1521.) C. BOSCIANUM Moq.
Dry, sandy soil, in open places; scarce.
North Sand Hill. Oct. 17, 1896.

The flowers much smaller than in allied species; on slender recurved branches; the black seeds easily separated from the enclosing pericarp. The first record for the State.

254. (1522.) C. BOTRYS L. Jerusalem Oak. Feather Geranium.
Waste places along the river front; scarce. June 28.

255. (1527.) C. HYBRIDUM L. Maple-leaved Goosefoot.
Borders of cultivated fields and banks of old canal; common. June 18.

256. (1533.) C. URBICUM L.
Commons and waste places about the city; frequent. June 15.

AMARANTHACEÆ. Amaranth Family.

121. AMARANTHUS L.

257. (1556.) A. GRAECIZANS L. Tumbleweed. White Pigweed.
(*A. albus* L.)
Waste, sandy places; common. July 20.

A specimen with the branches incurved to a globular form and measuring 5 feet, 7 inches in circumference, was taken from the old canal bed near Conover's Pond, in September, 1889.

258. (1561.) A. HYBRIDUS PANICULATUS (L.) Uline & Bray. Panicled Pigweed.
(*A. paniculatus* L.)
Fence rows along cultivated fields; frequent. July 1

259. (1564.) A. RETROFLEXUS L. Pig-weed. Red-root. Amaranth.
Cultivated grounds; very common. July 3.

260. (1565.) A. SPINOSUS L. Thorny Amaranth.
Roadsides and commons of city; frequent. July 15.

122. ACNIDA L.

261.* (1569.) A. TAMARISCINA (Nutt.) Wood. Water Hemp.
(*A. tuberculata* Moq.)
Gravel and sand banks of Wabash River; common. August 20.

261a.* (1570.) A. TAMARISCINA SUBNUDA (S. Wats.) Coulter.
(*A. tuberculata* var. *subnuda* Wats.)
Borders of ponds in wet, sandy soil; frequent.

Usually prostrate with the reddish flowers in dense, globular axillary heads.

PHYTOLACCACEÆ. Poke-weed Family.

123. PHYTOLACCA L.

262. (1575.) P. DECANDRA L. Poke-weed. Pigeon-berry. Poke-root.
Roadsides and fence rows in rich, moist soil; frequent. June 16.

AIZOACEÆ. Carpet Weed Family.

124. MOLLUGO L.

263. (1583.) M. VERTICILLATA L. Carpet Weed. Indian Chickweed.

Open, bare, sandy places and cultivated fields; common. May 11 to November 15.

PORTULACACEÆ. Purslane Family.

125. CLAYTONIA L.

264. (1589.) C. VIRGINICA L. Narrow-leaved Spring Beauty.

Moist, open woods; common. March 23.

Varies much in width and length of leaves, and in color of flowers from deep pink to almost white.

126. PORTULACA L.

265. (1593.) P. OLERACEA L. Common Purslane. Pusley.

Gardens and cultivated grounds; abundant. May 8.

CARYOPHYLLACEÆ. Pink Family.

127. AGROSTEMMA L.

266. (1596.) A. GITHAGO L. Corn Cockle.

(*Lychnis githago* L.)

Borders of railways and wheatfields; frequent. May 20.

A handsome, but vile weed.

128. SILENE L. Campions.

"To prevent ants, small beetles, and other honey-eating intruders from creeping up the stalk, and so rifling the nectaries without doing any good to the plant in return, the stems of the campions are covered with hairs, and exude a sticky, viscid gum, both of which peculiarities aid them in baffling the unwelcome wingless visitors, while the inflated calyx and long tube effectually keep out all flying insects, except the few for whose visits the plants specially lay themselves out. Nay, as if so many precautions were not enough, the mouth of the tube, above the stamens, is furthermore obstructed by five little valves, or scales, one being attached to the claw of each petal; and these scales can easily be craned over, like tiny walls, by the large and long proboscis of the bees or moths, but not by the little thieving flies against whose incursions the flowers are so anxious to guard themselves."—*Grant Allen.**

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* Vignettes from Nature, 11.

267. (1599.) S. ALBA Muhl. Snowy Campion.
(*S. nivea* Otth.)
Scarce. Taken on several occasions along the Vandalia and I. & St. L. Railways. June 4.

268. (1601.) S. ANTIRRHINA L. Sleepy Catchfly.
Waste places in dry, sandy soil; frequent. April 20.

269.* (1609a.) S. REGIA Sims Royal Catchfly.
Borders of prairies; rare.
East of Prairieton. June 22, 1890.

270. (1611.) S. STELLATA (L.) Ait. f. Starry Campion.
Shaded banks; scarce.
Sides of canal near Five Mile Pond. Van. Railway. June 11.

271. (1612.) S. VIRGINICA L. Fire Pink. Catchfly.
Ravines and borders of damp woods; scarce.
Coal Creek. Grant. April 25.

129. SAPONARIA L.

272. (1625.) S. OFFICINALIS L. Soapwort. Bouncing Bet.
Waste places in sandy soil; frequent. June 15.
Very abundant along the old canal near Five-Mile Pond.

130. ALSINE L.
(*Stellaria* L.)

273.* (1637.) A. LONGIFOLIA (Muhl.) Britton. Long-leaved Stitchwort.
(*Stellaria longifolia* Muhl.)
Open woods in rather damp places; scarce. May 25.

274. (1638.) A. LONGIPES (Goldie) Coville. Long-stalked Stitchwort.
(*Stellaria longipes* Goldie.)
Moist prairies and borders of marshes; rare. May 12.
Heckland. Marsh west of Beach's Woods near Van. Railway.

275. (1641.) A. MEDIA L. Common Chickweed.
(*Stellaria media* Smith.)
Rich, damp soil; frequent. March 20.
Borders of marsh south of Fair Ground. Streets of Terre Haute.

276. (1642.) A. PUBERA (Michx.) Britton. Great Chickweed.
(*Stellaria pubera* Michx.)
Open woods in rich soil; common. April 5.

131. CERASTIUM L.

277. (1650.) C. LONGIPEDUNCULATUM Muhl. Nodding Mouse-ear Chickweed.
(*Cerastium nutans* Raf.)
Moist, grassy places; frequent. April 20.

278. (1652.) C. VISCOSUM L. Mouse-ear Chickweed.
Grassy banks and roadsides; frequent. April 20.
Sand Hill. Coal Creek.

Paler green and not so spreading as the next.

279.* (1653.) C. VULGATUM L. Larger Mouse-ear Chickweed.
Open woods, meadows and waste places; common. April 28.

132. ARENARIA L.

280.* (1671.) A. SERPYLLIFOLIA L. Thyme-leaved Sandwort.
Low, moist, sandy places; scarce. May 31.
Borders of Conover's and Five-Mile ponds.

Not before recorded from Indiana south of the sand dunes bordering Lake Michigan.

NYMPHÆACEÆ. Water-Lily Family.

135. NELUMBO Adans.

281 (1687.) N. LUTEA (Willd.) Pers. Water Chinquapin. Yellow Nelumbo.
Ponds; scarce. June 20.

Previous to 1890 this was a common plant in the Goose and Five Mile ponds, the surfaces of which in late summer were extensively covered with the large peltate, circular, floating leaves often two and one-half to three and one-quarter feet in diameter. Since the total draining of the former and partial draining of the latter pond the plant has become almost exterminated in the county.

134. CASTALIA Salisb.
(*Nymphæa* Tourn.)

282. (1693.) C. TUBEROSA (Paine) Greene. White Water Lily.
(*Nymphæa reniformis* DC.)
Ponds; frequent. May 28.
Formerly very common at Goose Pond. Five-Mile Pond.

The flowers have a very distinct, agreeable odor, but the rootstocks are tuber-bearing.

135. NYMPHÆA L.

(*Nuphar* Smith.)

283. (1695.) N. ADVENA Soland. Yellow Pond Lily. Spatter-Dock.
(*Nuphar advena* Ait.)

Ponds, ditches and stagnant pools; common. April 28.

MAGNOLIACEÆ. Magnolia Family.

136. LIRIODENDRON L.

284. (1706.) L. TULIPIFERA L. Tulip Tree. Yellow Poplar

Open woods in rich soil; frequent. April 25.

Once abundant and the giant of the Indiana forests, reaching at times a height of 190 feet and a circumference of 25 feet.* All the larger ones have long since disappeared before the axe of the lumberman, and in Vigo County individuals more than 60 feet high are scarce.

ANONACEÆ Custard-Apple Family.

137. ASIMINA Adans.

285. (1707.) A. TRILOBA (L.) Dunal. Papaw.

Open woods, most common in rather low, rich soil. April 20.

The flowers expand a few days before the leaves appear. Those on the tips of branches are often a bright green instead of purplish red, as are those below. The fruit varies much in abundance, some years being very plentiful and again scarce. It is very rarely double, being united at stem end and by the skin at lower end. Two varieties of the fruit are readily distinguished, the pulp of one, when ripe, being whitish-yellow, and inferior in taste; of the other deep golden-yellow and very palatable.

RANUNCULACEÆ. Crowfoot Family.

138. HYDRASTIS L.

286. (1708.) H. CANADENSIS L. Yellow Root. Orange Root. Golden Seal.

Hillsides and rich, wooded slopes; scarce.

Woods east of St. Mary's. Coal Creek. Ferrell's. April 25.

A valued medicinal plant.

139. CALTHA L.

287. (1711.) C. PALUSTRIS L. Marsh Marigold.

Swamps and marshes; common locally.

East of Sand Hill. Canal three miles south of T. H. March 26.

An early and showy spring flower.

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*J. Schneck, Ind. Geol. Surv., VII, 1875, 512.

140. ISOPYRUM L.

288. (1715.) I. BITERNATUM (Raf.) T. & G. False Rue-anemone.
Moist, open woods and shady places; frequent. April 2.

Often mistaken for *Syndesmon thalictroides* (L.), but distinguished by having only five sepals, and by the small tubers on the root fibres.

141. ACTÆA L.

289. (1718.) A. ALBA (L.) Mill. White Baneberry.
Thickets and dense woods; frequent.
Ferrell's. Coal Creek, etc. April 28.

142. AQUILEGIA L.

290. (1726.) A. CANADENSIS L. Wild Columbine.
Dry, gravelly soil and rocky hillsides; scarce. April 28.
Coal Creek. Sides of canal near Ft. Harrison, and Five-Mile Pond.

143. DELPHINIUM L.

291. (1730.) D. CONSOLIDA L. Field Larkspur.
Roadsides and old fields; scarce. May 25.
Found two or three different seasons along the Vandalia railway.

292. (1731.) D. TRICORNE Michx. Dwarf Larkspur.
Open woods in rich soil; common. April 13.

Varies much in size of plant, and in color of flower from white to deep blue.

144. ANEMONE L.

293 * (1736.) A. CANADENSIS L. Pennsylvania Anemone.
(*A. pennsylvanica* L.)
Dry, gravelly soil; scarce. May 21.
Old canal near Conover's pond. I. & St. L. Railway on west side of Wabash River.

294. (1737.) A. CAROLINIANA Walt. Carolina Anemone.
Borders of prairies and dry, open hillside woods; rare. April 15, 1894.
Collected by Miss Nora Arnold.*

The first record for the State.

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* In a private letter Miss Arnold states: "They grow abundantly on the hillside 5½ miles north of Terre Haute, along the Durkey's Ferry road, on the east side of the river. In patches or spots the ground when they bloom is white with them. They have occurred there within my memory for twelve or thirteen years.

295.* (1744.) A. **VIRGINIANA** L. Virginia Anemone.
Loose, rich soil; rather common. May 14.
Banks of canal and along the railways.*

145. HEPATICA Scop.

296. (1745.) H. **ACUTA** (Pursh) Britton. Liverleaf. Sharp-lobed Hepatica.
(*H. acutiloba* D C.)
Sides of ravines and dry open woods; common. March 10.

Five-lobed leaves are occasionally found, and the sepals vary exceedingly in color and number.

146. SYNDESMON Hoffmg.

(*Anemonella* Spach.)

297 (1747.) S. **THALICTROIDES** (L) Hoffmg. Rue–anemone.
(*Anemonella thalictroides* Spach.)
Open, upland woods; common March 15.

147. CLEMATIS L.

298. (1755.) C. **SIMSII** Sweet.
(*C. pitcheri* T. & G.)
Banks of railways (Vandalia and E. & T. H.), and old canal near Five-mile Pond; scarce. June 1.

The plumose tails of the fruit very noticeable in early autumn.

299. (1756.) C. **VIORNA** L. Leather Flower.
Dry, gravelly banks; rare. May 25.
Alongside of Van. Railway, near Beach's woods.

300. (1757. C. **VIRGINIANA** L. Virgin's Bower. White Clematis.
Borders of thickets, especially along streams and in low places; frequent. June 20.
Coal Creek. Honey Creek. Ferrell's.

148. RANUNCULUS L.

301. (1761.) R. **ABORTIVUS** L. Small-Flowered Crowfoot.
Open woods in damp soil; common. April 10.

302.* (1765.) R. **DELPHINIFOLIUS** Torr. Yellow Water Crowfoot.
(*R. multifidus* Pursh.)
Ponds; frequent. April 21.

***A. nemorosa* L is noted as "common" in several of the local lists of the State, and is given without comment in the State Catalogue, yet I have failed to find a specimen in either Monroe or Vigo counties. *Syndesmon thalictroides* (L), to which it bears a close general resemblance, is doubtless often mistaken for it.

303. (1766.) R. FASCICULARIS Muhl. Early Buttercup.
Hillsides in sandy soil; frequent. April 7.
East of Five-Mile Pond. Sand Hill.

304. (1772) R. MICRANTHUS Nutt.
(*R. abortivus micranthus* Gray.)
Pastures and roadsides in dry or sandy soil; frequent. April 10.
Taken in fruit on April 17.

305. (1776.) R. OBTUSIUSCULUS Raf. Water Plantain. Spearwort.
(*R. ambigens* Watson.)
Borders of ponds; rare.
Noted only at Goose Pond. June 22, 1890.
Taken before in Indiana only in Noble County.

306. (1783.) R. PURSHII Richards.
(*R. multifidus terrestris* Gray.)
Noted only along the margins of Five-Mile Pond. April 21.
The first record for the State.

307. (1786.) R. RECURVATUS Poir. Hooked Crowfoot.
Open woods; common. April 20.
The petals often six, and the root leaves larger than in other species of the genus; sometimes ternately divided.

308. (1790.) R. SCELERATUS L. Cursed Crowfoot.
Borders of ditches and marshes; scarce. June 1.
South of Fair Ground. Heckland.

309. (1791.) R. SEPTENTRIONALIS Poir. Creeping Buttercup.
Low, wet meadows; river bottoms, margins of ponds, ditches, etc. Common and very variable. April 18.

149. BATRACHIUM S. F. Gray.

310.* (1794.) B. TRICHOPHYLLUM (Chaix) Bossch. White Water-Crowfoot.
(*Ranunculus aquatilis* var. *trichophyllus* Gray.)
Ponds; frequent. April 20.
Old Canal south of Spring Hill. Five-Mile Pond. Goose Pond.

150. THALICTRUM L.

311. (1801.) T. DIOICUM L. Early Meadow-rue.
Wooded hillsides and loose, rich soil in waste places; frequent. April 8.
Honey Creek. Van. Railway.

312. (1802.) T. POLYGAMUM Muhl. Tall Meadow-rue.
Borders of ditches and swampy places; scarce.
Heckland. June 18.

313.* (1803.) T. PURPURASCENS L. Purplish Meadow-rue.
Dry upland soil and margins of prairies; frequent.
Van. Railway. Heckland. E. & T. H Railway. May 16.

BERBERIDACEÆ. Barberry Family.

151. PODOPHYLLUM L.

314. (1806.) P. PELTATUM L. May Apple. Mandrake.
Open woods in rich soil; abundant. April 27.

152. JEFFERSONIA Bart.

315. (1807.) J. DIPHYLLA (L.) Pers. Twin-leaf. Rheumatism Root.
Rich, sloping hillsides; scarce.
Coal Creek. Grant. April 16.

The leaflets often five to seven-lobed.

153. CAULOPHYLLUM Michx.

316.* (1809.) C. THALICTROIDES (L.) Michx. Blue Cohosh. Pappoose Root.
Wooded hillsides, usually near the bottom, in rich, moist soil; scarce.
Honey Creek. Coal Creek. April 11.

MENISPERMACEÆ. Moonseed Family.

154. MENISPERMUM L.

317. (1813.) M. CANADENSE L. Moonseed.
Borders of low-ground thickets and fence rows; frequent. May 20.

A handsome, slender, woody climber, with rounded peltate leaves, small panicles of white, inconspicuous flowers, and fruit in early autumn resembling wild grapes in compact, rounded bunches.

LAURACEÆ. Sassafras Family.

155. SASSAFRAS Nees and Eberm.

318. (1819.) S. SASSAFRAS (L.) Karst. Sassafras.
(*S. officinale* Nees.)
Borders of rich woods and old fields; frequent. April 10.

156. BENZOIN Fabric.

(*Lindera* Thunb.)

319. (1821.) B. BENZOIN (L.) Coulter. Spice-bush. Benjamin-bush.
(*Lindera benzoin* Blume.)
Dense, moist woods and sides of ravines; frequent.
Woods near Broadhurst's mine. Ferrell's, etc. April 5.

PAPAVERACEÆ. Poppy Family.

157. SANGUINARIA L.

320. (1823.) S. CANADENSIS L. Blood-root. Coon-root.
Open woods in rich soil; common. March 17.

158. STYLOPHORUM Nutt.

321. (1824.) S. DIPHYLLUM (Michx.) Nutt. Celandine Poppy.
Moist, rich soil near the foot of wooded slopes or in ravines; scarce.
Honey Creek. Coal Creek. April 17.

159. BICUCULLA Adans.

(*Dicentra* Borkh.)

322.* (1834.) B. CANADENSIS (Goldie) Millsp. Squirrel Corn.
(*Dicentra canadensis* DC.)
Wooded slopes and sides of ravines; not so common as the next species and blooming about 10 days later.
Woods east of St. Mary's. Coal Creek. Southeast of Hunt's Rosary. April 14.

323.* (1835.) B. CUCULLARIA (L.) Millsp. Dutchman's Breeches.
(*Dicentra cucullaria* DC.)
Open woods in moist, rich soil; frequent. April 5.

160. CAPNOIDES Adans.

(*Corydalis* Vent.)

324.* (1841.) C. FLAVULUM (Raf.) Kuntze. Yellow Corydalis.
(*Corydalis flavula* Raf.)
Open woods in rich, sandy soil; scarce.
Sand Hill. Southeast of Hunt's. Beach's woods. April 13.

CRUCIFERÆ. Mustard Family.

161. LEPIDIUM L.

325. (1851.) L. INTERMEDIUM A. Gray. Wild Pepper-grass.
Waste places in dry or gravelly soil; common. May 10.

L. intermedium has *fewer*, narrower and more entire leaves, and the racemes are longer and more spreading than in *L. virginicum* L. In the latter the flowers have a tendency to agglomeration, and the leaves are narrowly spatulate, rather than linear, with the edges more incised.

The first record for the State, this species and the next not having been distinguished by previous cataloguers.

326. (1854.) L. VIRGINICUM L. Wild Pepper-grass. Tongue-grass.
Roadsides and fields; common. May 1 to November 15.

162. SISYMBRIUM L.

327. (1863.) S. OFFICINALE (L.) Scop. Hedge Mustard.
Waste places, old fields, roadsides, etc.; common. May 24.

163. BRASSICA L.

328. (1867.) B. NIGRA (L.) Koch. Black Mustard.
Roadsides and waste places; frequent. July 1.

329. (1868.) B. SINAPISTRUM Boiss. Field Mustard. Charlock.
Old fields; not common.
Near Ft. Harrison. May 21.

164. IODANTHUS T. and G.

(*Thelypodium* Endl.)

330. (1874.) I. PINNATIFIDUS (Michx.) Prantl. False Rocket.
(*Thelypodium pinnatifidum* S. Wats.)
Moist hillside thickets; scarce.
I. & St. L. R. R. Southeast of Hunt's. Coal Creek. May 10.

165. RORIPA Scop.

(*Nasturtium* R. Br.)

331.* (1875.) R. AMERICANA (A. Gray) Britton. Lake Cress.
(*Nasturtium lacustre* Gray.)
Ponds; frequent.
Conover's and Five-Mile ponds. Goose Pond. May 22.

332. (1876.) R. ARMORACIA (L.) A. S. Hitchcock. Horse-radish.
(*Nasturtium armoracia* Fries.)
Moist soil; escaped from cultivation; scarce.
Southeast of Hunt's. Grant. May 10.

333. (1879.) R. NASTURTIUM (L.) Rusby. True Water Cress.
(*Nasturtium officinale* R. Br.)
Brooks and ditches; probably introduced; not common.
Sand Hill. Ditch near Five-Mile Pond. April 23.

334. (1881.) R. PALUSTRIS (L.) Bess. Marsh Cress.
(*Nasturtium palustre* DC.)
Borders of ponds in shallow water; frequent. May 10.

335.* (1882.) R. SESSILIFLORA (Nutt.) A. S. Hitchcock. Pond Cress.
(*Nasturtium sessiliflorum* Nutt.)
Mucky margins of ponds; frequent.
South of Fair Ground. Conover's and Five-Mile ponds. April 30.

Though mentioned in several of the lists of Indiana plants, the range is given in Gray's Manual as "W. Ill. to E. Kan. and southward."

166. CARDAMINE L.

336. (1888.) C. BULBOSA (Schreb.) B. S. P. Spring Cress.
(*C. rhomboidea* DC.)
Wet, shady soil; frequent.
Heckland. Ferrell's. Southeast of Hunt's. April 13.

337. (1890.) C. DOUGLASSI (Torr.) Britton. Purple Spring Cress.
(*C. rhomboidea purpurea* Torr.)
Open woods in rather dry soil; common. February 9.

The first Crucifer to bloom in spring.

338. (1892.) C. HIRSUTA L. Small Bitter Cress.
Low wet places; frequent.
South of Fair Ground. Sand Hill, etc. April 2.

167. DENTARIA L.

339. (1899.) D. LACINIATA Muhl. Toothwort. Pepper-root.
Moist open woods; common. March 22.

The leaves variable in form and the flowers in color.

168. BURSA Weber.

(*Capsella* Medic.)

340. (1914.) B. **BURSA-PASTORIS** (L.) Weber. Shepherd's Purse.

(*Capsella bursa-pastoris* Medic.)

Waste places; abundant.

In flower March 10 and as late as November 25.

169. DRABA L.

341.* (1919.) D. **CAROLINIANA** Walt. Carolina Whitlow Grass.

Sandy soil in open fields and meadows; frequent.

Hillside south of Conover's pond. Canal at Ft. Harrison. March 14.

Rising less than three inches above the ground, the little Draba blooms on the first warm days of March and its seeds are ripened by mid-April. Its work is, therefore, over before that of many plants is begun. It succeeds in the struggle for existence by being first upon the scene of action. Drinking long and deep of the bright spring sunshine, it soon gives way to its competitors, but not before its life's duty, the perpetuation of its kind, has been fulfilled.

170. DESCURAINIA Webb and Barth.

342.* (1930.) D. **PINNATA** (Walt.) Britton. Tansy Mustard.

(*Sisymbrium canescens* Nutt.)

Gravelly soil; frequent.

E. & T. H. and Vandalia Railways. Sides of canal. April 20.

171. ARABIS L.

343.* (1934.) A. **CANADENSIS** L. Sickle-pod.

Sandy or gravelly soil; rare.

Side hill near the Seventh Street bridge across Lost Creek. June 4.

344.* (1936.) A. **DENTATA** T. and G. Toothed Rock Cress.

Taken but once, in McKeen's woods west of Sand Hill. May 3, 1891.

345. (1938.) A. **HIRSUTA** (L.) Scop. Hairy Rock Cress.

Rocky hillsides or dry, gravelly soil; rare.

Found but once, May 21, 1891, on sides of canal above Conover's pond. This is the first published record for the State, though the plant has been taken by the writer in Monroe and Montgomery Counties.

346. (1940.) A. LAEVIGATA (Muhl.) Poir. Smooth Rock Cress.
Sides of ravines in dry soil; frequent.
Grant. Honey Creek. Coal Creek. April 10.

172. ERYSIMUM L.

347. (1944.) E. ASPERUM DC. Western Wallflower.
Gravelly banks; scarce.
Sides of canal near Ft. Harrison. I. & St. L. R. R. May 22.

CAPPARIDACEÆ. Caper Family.

173. POLANISIA Raf.

348. (1957.) P. GRAVEOLENS Raf.
Dry, gravelly soil; scarce.
Banks of canal. I. & St. L. R. R. June 17.

CRASSULACEÆ. Orpine Family.

174. SEDUM L.

349. (1977.) S. TELEPHIOIDES Michx.
Rocky hillsides; rare.
Noted only at Coal Creek, where it was collected by Dr. B. W. Evermann in 1889. April 30.

350. (1979.) S. TERNATUM Michx. Stone-crop.
Sides of ravines in damp places; scarce.
Grant. Honey Creek. Coal Creek. May 12.

175. PENTHORUM L.

351.* (1983.) P. SEDOIDES L. Ditch Stone-crop.
Low, wet places; common. July 15.

SAXIFRAGACEÆ. Saxifrage Family.

176. SAXIFRAGA L.

352.* (2000.) S. PENNSYLVANICA L. Swamp Saxifrage.
Damp woods and prairies; scarce.
Heckland. May 25.

177. HEUCHERA L.

353. (2006.) H. AMERICANA L. Common Alum-root.
Ravines and rocky hillsides; scarce. April 15.
Coal Creek. Heckland.

354*. (2007.) H. HISPIDA Pursh. Hispid Alum-root.
Dense, damp woods; scarce. June 8.
Noted only at Heckland, and first recorded in the State from there. (See Proc. Ind. Acad. Science, 1894, 105.) The only other known station in Indiana is Tolleston, Lake County. (*Id.*, 1895, 187.)

178. MITELLA L.

355. (2012.) M. DIPHYLLA L. Mitre-wort. Bishop's Cap.
Wooded hillsides and ravines; scarce. April 20.
Coal Creek. Honey Creek.

A delicate and handsome spring flower; the slender racemes often 10 to 12 inches in length.

179. HYDRANGEA L.

356. (2025.) H. ABORESCENS L Wild Hydrangea.
Sides of ravines and rocky banks; frequent. June 17.

One specimen, having only sterile, radiant flowers, was taken July 8, 1894.

180. RIBES L.

357. (2032.) R. CYNOSBATI L. Prickly Wild Gooseberry.
Wooded hillsides and banks of streams; frequent. April 20.

358.* (2034.) R. GRACILE Michx. Missouri Gooseberry.
Dry, upland woods; frequent.
Sand Hill. Honey Creek Hills. The only known locality in the State.* April 18.

359. (2037.) R. OXYACANTHOIDES L. Smooth Wild Gooseberry.
Damp, upland woods; scarce.
Sand Hill. (Auct. B. W. Evermann.) April 20, 1889.

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*See Coulter, Stanley, in Proc. Ind. Acad, Sci., 1894, 106.

HAMAMELIDACEÆ. Witch-Hazel Family.

181. HAMAMELIS L.

360. (2044.) H. VIRGINIANA L. Witch-Hazel.

Damp, upland woods; scarce.

Noted only in woods in S. W. ¼ Sec. 6, Pierson Tp. October 10.

"The witch-hazel is an extremely interesting plant, October and November child, and yet reminds me of the very earliest spring. Its blossoms smell like the spring, like the willow catkins. By their color, as well as fragrance, they belong to the saffron dawn of the year, suggesting among all these signs of autumn, falling leaves and frost, that the life of nature by which she eternally flourishes is untouched. It stands here in the shadow on the side of the hill, while the sunlight from over the top of the hill lights up its topmost sprays and yellow blossoms. Its spray, so jointed and angular, is not to be mistaken for any other. I lie on my back with joy under its boughs. While its leaves fall, its blossoms spring. The autumn, then, is indeed a spring."*—*Thoreau.*

182. LIQUIDAMBAR L.

361. (2045.) L. STYRACIFLUA L. Sweet Gum. Bilsted.

Low, damp soil; frequent along the Wabash River and borders of ponds and sloughs, especially in the southwestern part of the county. April 8.

PLATANACEÆ. Plane-tree Family.

183. PLATANUS L.

362. (2046.) P. OCCIDENTALIS L. Sycamore. Buttonwood.

Low, moist, usually alluvial soil; common. April 18.

One of the largest of our native trees, sometimes reaching a height of 176 feet and a diameter† of 10½ feet. The leaves of young specimens, growing in favorable localities, are also very large, one having been measured which was 19x15½ inches. Many large sycamores are still to be found in the forests skirting the Wabash in the southwestern part of the county.

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*Autumn, p. 87.

†Dr. J. Schneck, Ind. Geol. Surv., 1875, 512.

ROSACEÆ. Rose Family.

184. SPIRÆA L.

363. (2049.) S. SALICIFOLIA L. Common Meadow Sweet.
Margins of wet prairies; not common. June 15.
Heckland.
A form with pods included in calyx lobes is found sparingly.

185. PYRUS L.

364. (2057.) P. CORONARIA L. American Crab Apple.
Open, upland woods and fence rows; frequent. May 5.
Side of canal above Conover's Pond. Honey Creek hills, etc.
Noted for the beauty of its flowers and the sweetness of their perfume.

365. (2059.) P. MALUS L. Wild Apple.
Escaped and growing spontaneously in old fields; frequent.

"Here on this rugged and woody hillside has grown an apple tree, not planted by man, no relic of a former orchard, but a natural growth, like the pines and oaks. The owner knows nothing of it. The day was not observed when it first blossomed, nor when it first bore fruit, unless by the chickadee. There was no dancing on the green beneath it in its honor, and now there is no hand to pluck its fruit—which is only gnawed by squirrels, as I perceive. Who knows but this chance wild fruit, planted by a cow or bird on some remote and rocky hillside, where it is as yet unobserved by man, may be the choicest of all its kind, and foreign potentates shall hear of it, and royal societies seek to propagate it, though the virtues of the, perhaps, truly crabbed owner of the soil may never be heard of—at least, beyond the limits of his village? It was thus the Porter and the Baldwin grew.

"Every wild apple shrub excites our expectation thus, somewhat as every wild child. It is, perhaps, a prince in disguise. What a lesson to man! So are human beings, referred to the highest standard, the celestial fruit which they suggest and aspire to bear, browsed on by fate; and only the most persistent and strongest genius defends itself and prevails, sends a tender scion upward at last, and drops its perfect fruit on the ungrateful earth. Poets and philosophers and statesmen thus spring up in the country pastures, and outlast the hosts of unoriginal men."*—*Thoreau.*

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* The Succession of Forest Trees and Wild Apples, pp. 63, 69.

186. ARONIA Pers.

366.* (2063.) A. ARBUTIFOLIA (L.) Ell. Choke-berry.

(*Pyrus arbutifolia* L.)

Damp upland woods; rare.
Noted only at Heckland. May 22.

187. AMELANCHIER Medic.

367. (2066.) A. BOTRYAPIUM (L. f.) DC. Service Berry. Shad Bush.

(*A. canadensis oblongifolia* T. and G.)

Borders of damp woods; scarce.
Side of National Road near Sugar Creek. April 21.

188. CRATAEGUS L.

368. (2072.) C. COCCINEA L. Scarlet-fruited Hawthorn.
Borders of dry, upland woods; frequent.
Sand Hill. Coal Creek. Honey Creek, etc. May 1.

The leaves of this species are thinner and more sharply toothed than any other; while the fruit is small and more bitter than any except that of *C. tomentosa* L.

369. (2075.) C. CRUS GALLI L. Cockspur Thorn.
Borders of upland thickets; frequent.
Heckland. Coal Creek. Honey Creek. May 6.

Readily known by its small, thick, shining, obovate leaves, and abundant globose red fruit.

370. (2079.) C. MOLLIS (T. & G.) Scheele. Sweet-fruited Red Haw.

(*C. coccinea mollis* T. and G.)

Open hillside woods in rich soil, and borders of streams; frequent. April 20.

Leaves thicker and broader, and fruit rather larger, ripening earlier, and more agreeable to the taste, than that of the other species found in the county.

371.* (2081.) C. PUNCTATA Jacq. Yellow-fruited Hawthorn. Hog Haw.
Open, wooded slopes; scarce. May 2.
On the hillside north of Highland Lawn Cemetery a single specimen, bearing greenish-yellow fruit fully one inch broad, was noted October 16, 1896.

372. (2085.) C. TOMENTOSA L. Black Hawthorn. Pear Thorn.
Low, rich ground along streams; often forming thickets; common. May 10.

Form of leaves very variable; flowers blooming later and more ill scented, and the red globose fruit more bitter than that of any other of our species.

189. RUBUS L.

373. (2090.) R. BAILEYANUS Britton. Trailing Blackberry.
(*R. villosus humifusus* T. & G.)
Borders of woods, especially in sandy soil; frequent. May 19.

374.* (2091.) R. CANADENSIS L. Low Blackberry. Dewberry.
Old upland fields and roadsides; frequent. May 13.
South of St. Mary's. Near Glen, etc.

375. (2096.) R. HISPIDUS L. Running Swamp Blackberry.
Damp, flat woods; scarce.
Heckland. Beach's woods, close to Van. railroad.

376. (2100.) R. OCCIDENTALIS L. Black Raspberry. Thimble-berry.
Borders of upland thickets and fence rows; common. May 27.

377. (2106.) R. VILLOSUS Ait. Common High Blackberry.
Open woods, fence rows, etc.; common. May 27.

190. FRAGARIA L.

378. (2112.) F. VESCA L. Wood Strawberry.
Dry or gravelly soil; common. April 21.
Along canal and railways.

379. (2113.) F. VIRGINIANA Duchesne. Wild Strawberry.
Moist wooded banks; scarce.
Southeast of Hunt's. Roadside near Glen.

191. POTENTILLA L.

380. (2120.) P. CANADENSIS L. Common Cinque-foil. Five-finger.
Old fields and along roadsides in poor or "worn out" soil; common. May 12.

381. (2127.) P. MONSPELIENSIS L. Cinque-foil.
(*P. norvegica* L.)

Borders of open dry woods; scarce.
Sand Hill. Coal Creek. June 15.

192. GEUM L.

382. (2141.) G. CANADENSE Jacq. White Avens.
(*G. album* Gmel.)

Borders of woods and thickets; frequent. May 2.

383 * (2144.) G. MACROPHYLLUM Willd.
Borders of open, rich woods; rare.
McKeen's woods south of the Fair Ground. June 26.
The first record for the State.

384. (2149.) G. VERNUM (Raf.) T. and G. Spring Avens.
Thickets and fence rows; common. April 21.

193. ULMARIA Hill.

385. (2155.) U. RUBRA Hill. Queen of the Prairie.
(*Spiræa lobata* Gronov.)

Damp meadows and prairies; scarce.
Rather common in the prairies north of Heckland. June 30, 1891.
One of the most handsome of the prairie plants, now so rapidly disappearing.

194. AGRIMONIA L.

386. (2160.) A. PARVIFLORA Soland. Small-flowered Agrimony.
Along gravelly banks and borders of thickets; scarce. May 25.

387. (2161.) A. STRICTA Michx. Common Agrimony.
(*A eupatoria* L.)

Borders of upland woods and fence rows; common. May 12.

195. SANGUISORBA L.
(*Poterium* L.)

388.* (2162.) S. CANADENSIS L. Canadian Burnet.
(*Poterium canadense* Benth. & Hook.)
Borders of ditches, and prairies in moist soil; scarce.
Heckland and side of T. H. & L. Railway north of Otter Creek Junction. In flower from August 10 to October 20.
The first record for the State.

196. ROSA L.

389. (2168.) R. CAROLINA L. Swamp Rose.
Borders of swamps and ditches; growing in dense clumps; common. June 1.

390.* (2169.) R. HUMILIS Marsh. Dwarf Wild Rose.
Dry, usually gravelly or sandy soil; frequent.
Along railways, especially T. H. & L. near Heckland. June 1.

391. (2172.) R. RUBIGINOSA L. Sweet Brier. Eglantine.
Waste places and roadsides; frequent.
Old canal. Roadsides near St. Mary's, etc. May 26.

"The seed vessel of the sweet brier is a very beautiful, glossy, elliptical fruit. This shrub, what with the fragrance of its leaves, its blossoms, and its fruit, is thrice crowned."—*Thoreau.*

392. (2174.) R. SETIGERA Michx. Climbing or Prairie Rose.
Borders of prairies and thickets; scarce.
Heckland. June 13.

Our most handsome species; often cultivated.

197. PRUNUS L.

393. (2177.) P. AMERICANA Marsh. Wild Yellow or Red Plum.
Banks of streams and borders of moist, upland thickets; frequent, especially in southern half of county. April 21.

394. (2190.) P. SEROTINA Ehrh. Wild Black Cherry.
Rich, upland woods, fence-rows, etc.; common. May 10.

LEGUMINOSÆ. Pulse Family.

198. CERCIS L.

395. (2201.) C. CANADENSIS L. Red-bud. Judas Tree.
Open woods and borders of thickets in dry, rich soil; common April 14.

199. CASSIA L.

396. (2202.) C. CHAMÆCRISTA L. Partridge Pea.
Sandy banks of old canal; common. April 30.

397. (2204.) C. MARYLANDICA L. Wild Senna.
Sand or gravel bars and low, waste grounds; frequent. August 20.

200. GLEDITSCHIA L.

398. (2209.) G. TRIACANTHOS L. Honey Locust. Thorn Tree.
Open woodlands and fence-rows; common. May 27.

Specimens twenty feet high and less are very thorny; tall, old trees are often nearly destitute of thorns.

201. GYMNOCLADUS Lam.

399. (2210.) G. DIOICUS (L.) Koch. Kentucky Coffee Tree.
(*G. canadensis* Lam.)

Rich open upland or river terrace woods; frequent. May 26.

Reaches a diameter of 18 to 20 inches. The large pods and beans are often objects of special interest to persons who are unacquainted with the tree.

202. BAPTISIA Vent.

400. (2219.) B. LEUCANTHA T. and G. White False Indigo.
Moist prairies; frequent.
Common at Heckland. Sides of railway above Otter Creek Junction. S. W. ¼ of S. E. ¼, Sec. 6, Pierson Township. May 20.

The pods, when mature, are variable in length, and obliqueness of base.

203. MEDICAGO L.

401.* (2236) M. LUPULINA L. Black Medick. Nonesuch.
Waste places along railways; scarce.
Sides of Vandalia R. R. E. & T. H. Railway south of the blast furnace. May 20.

204. MELILOTUS Juss.

402. (2238.) M. ALBA Lam. White Sweet Clover.
Dry gravelly soil in waste grounds; frequent.
Sides of canal. Crossing of I. & St. L. Railway and St. Mary's Road. May 27.

Sometimes reaches a height of six feet and forms dense thickets, which, when the plants are old, are difficult to penetrate.

403. (2239.) M. OFFICINALIS (L.) Lam. Yellow Sweet Clover.
Dry or alluvial soil; scarce.
Side of Vandalia Railway, one mile east of Terre Haute. June 12.

205. TRIFOLIUM L.

404. (2248.) T. PRATENSE L. Red Clover.
Roadsides and meadows; abundant. May 14.

A white-flowered form occurs sparingly.

405. (2250.) T. REFLEXUM L. Buffalo Clover.
Dry, sandy hillsides or prairies; rare.
Hillside east of Five-Mile Pond. May 28.

406. (2251.) T. REPENS L. White Clover.
Fields and roadsides; common. May 10.

206. PSORALEA L.

407.* (2265.) P. ONOBRYCHIS Nutt.
Moist soil along railways; frequent.
Side of T. H. & L. near Heckland. E. & T. H. near Spring Hill. June 8.

408.* (2266.) P. PEDUNCULATA (Mill.) Vail.
(*P. melilotoides* Michx.)

Dry, sandy soil; frequent.
Common along railway near Heckland. June 8.

207. AMORPHA L.

409.* (2269.) A. CANESCENS Pursh. Lead-plant. Wild Tea.
Sandy hillsides and prairies; scarce.
Near Five-Mile Pond. June 17.

Its presence was formerly supposed to indicate deposits of lead ore, whence one of the common names.

410. (2270.) A. FRUTICOSA L. False Indigo. River Locust.
Sandy or gravelly banks; frequent.
Along the old canal, both north and south of Terre Haute.

208. KUHNISTERA Lam.
(*Petalostemon* Michx.)

411. (2276.) K. CANDIDA (Willd.) Kuntze. Prairie-clover.
(*Petalostemon candidus* Michx.)
Dry prairie soil; scarce.
Hillside near Five-Mile Pond. Vandalia Railway near gravel pit, etc. June 27.

412.* (2280.) K. PURPUREA (Vent.) MacM. Prairie-clover.
(*Petalostemon violaceus* Michx.)
With the above, but more common. June 27.

209. CRACCA L.
(*Tephrosia* Pers.)

413. (2286) C. VIRGINIANA L. Goat's Rue. Catgut. Hoary Pea.
(*Tephrosia virginiana* Pers.)
Sandy hillsides; scarce.
Near Five-Mile Pond. May 15.

210. ROBINIA L.

414. (2289.) R. PSEUDACACIA L. Black Locust. False Acacia.
Naturalized; dry or sandy upland soil; frequent.
Beach's woods. Sides of canal, etc. May 12.

211. MEIBOMIA Adans.
(*Desmodium* Desv.)

415. (2336.) M. BRACTEOSA (Michx.) Kuntze. Tick Trefoil.
(*Desmodium cuspidatum* Torr. & Gray.)
Damp thickets and borders of prairies; scarce.
Heckland. Ferrell's. July 1.

416. (2337.) M. CANESCENS (L.) Kuntze. Seed Ticks.
(*Desmodium canescens* DC.)
Borders of woods and thickets in rich soil; common.

417. (2338.) M. CANADENSIS (L.) Kuntze.
(*Desmodium canadense* DC.)
Moist open woods and copses; frequent. July 1.

418. (2340.) M. DILLENII (Darl.) Kuntze.
(*Desmodium dillenii* Darl.)
Dry, open woods; frequent.
Coal Creek. Southeast of Hunt's. Honey Creek.

419. (2341.) M. GLABELLA (Michx.) Kuntze.
(*Desmodium humifusum* Beck.)
Sandy soil; frequent.
Sides of canal near Five-Mile Pond. Roadside near Heckland. June 15.

420. (2342.) M. GRANDIFLORA (Walt.) Kuntze.
(*Desmodium acuminatum* DC.)
Rich, moist woods; frequent.
East of St. Mary's. Ferrell's. June 15.

421. (2346.) M. MARYLANDICA (L.) Kuntze.
(*Desmodium marilandicum* Boott.)
Damp thickets and woodlands; scarce.
Heckland.

422. (2347.) M. NUDIFLORA (L.) Kuntze. Tick Trefoil.
(*Desmodium nudiflorum* DC.)
Dry, open woods; frequent.
Coal Creek. Beach's. June 5.

423. (2356.) M. ROTUNDIFOLIA (Michx.) Kuntze. Round-leaved Tick Trefoil.
(*Desmidium rotundifolium* DC.)
Dry, upland, wooded hillsides; scarce.
Coal Creek. Grant. Hipple's Coal-mine Woods. June 20.

424. (2357.) M. SESSILIFOLIA (Torr.) Kuntze.
(*Desmodium sessilifolium* T. and G.)
Frequent in dry, sandy soil.
Side of canal. Five-Mile Pond. Van. R. R. Beach's Woods. June 2.

212. LESPEDEZA Michx.

425. (2361.) L. ANGUSTIFOLIA (Pursh.) Ell.
Dry prairie; scarce.
Heckland, by side of T. H. & L. R. R. August 18.
The first record for the State.

426. (2362.) L. CAPITATA Michx.
Prairies and sandy soil; frequent.
Hillside near Five-mile Pond. Heckland. Borders of canal, both north and south of Terre Haute, etc. August 10.

427. (2365.) L. FRUTESCENS (L.) Britton.
(*L. reticulata* Pers.)
Sandy soil, margins of prairies, etc.; frequent.
Hillside near Five-mile pond. Heckland. Hipple's Coal-mine woods. August 5.

428. (2370.) L. PROCUMBENS Michx. Trailing Bush Clover.
Dry sandy soil; not common.
Bed of canal near Fort Harrison. Heckland. July 20.

429. (2375.) L. VIOLACEA (L.) Pers.
Dry upland woods; frequent.
Coal Creek. Heckland. Hipple's Coal-mine woods. July 23.

213. LATHYRUS L.

430. (2389.) L. MYRTIFOLIUS Muhl.
(*L. palustris myrtifolius* Gray.)
Moist banks; scarce.
Sides of T. H. & L. R. R., below Heckland. June 1.

431.* (2392.) L. PALUSTRIS L. Marsh Vetchling.
Borders of ditches and ponds; scarce.
Ditch side, near station of Heckland. Goose Pond. May 17.

214. FALCATA Gmel.
(*Amphicarpœa* Ell.)

432. (2397.) F. COMOSA (L.) Kuntze. Hog Peanut.
(*Amphicarpœa monoicœa* Nutt.)
Damp woodlands in rich soil; common. July 25.

Leaflets never more than two inches in length; pods, two to five, seven-eighths of an inch long, borne on a short rachis; seeds, three mm. in length.

433. (2399.) F. PITCHERI (T. and G.) Kuntze. Large-leaved Hog Peanut.
(*A. pitcheri* T. and G.)
Hillside thickets in damp rich soil; scarce.
Coal Creek.

Leaflets much larger than in *F. comosa* (L.), the blade often more than three inches long; pods, ten or more, 1½ inches long, borne on a long hairy rachis; seeds, 5 mm. in length.

The first record for the State.

215. APIOS Moench.

434.* (2399.) A. APIOS (L.) MacM. Ground Nut.
(*A. tuberosa* Moench.)
Borders of moist woods and marshes; scarce.
Heckland. Ferrell's. Goose Pond. August 15.

216. PHASEOLUS L.
(*Strophostyles* Ell.)

435. (2402.) P. HELVOLUS L. Wild Bean.
(*Strophostyles angulosus* Ell.)
Dry or sandy banks and hillsides; frequent.
Sides of canal and railways. July 27.

436.* (2406.) P. UMBELLATUS (Muhl.) Britton. Wild Bean.
(*Strophostyles peduncularis* Ell.)
Sandy soil; scarce.
Canal near Five-Mile Pond. July 22.

GERANIACEÆ. Geranium Family.

217. GERANIUM L.

437. (2411.) G. CAROLINIANUM L. Carolina Cranesbill.
Dry, gravelly banks; frequent.
Common along the railways and banks of canal. May 10.

438. (2414.) G. MACULATUM L. Wild Cranesbill. Wild Geranium.
Open woods and thickets; frequent. April 20.

OXALIDACEÆ. Oxalis Family.

218. OXALIS L.

439. (2424.) O. STRICTA L. Yellow Wood-sorrel.
(*O. corniculata stricta* Savigny.)
Open woods and roadsides; common. May 3 to November 4.

440. (2425.) *O. violacea* L. Violet Wood-sorrel.
Moist soil in woods and open places; scarce,
Ferrell's. Ravine northeast of Five-Mile Pond. May 3.

LINACEAE. Flax Family.

219. LINUM L.

441. (2433.) L. VIRGINIANUM L. Wild Flax.
Dry, sandy soil; scarce.
Hillside, near Five-Mile Pond. Heckland. July 20.

RUTACEAE. Rue Family.

220. ZANTHOXYLUM L.

442. (2435.) Z. AMERICANUM Mill. Prickly Ash. Toothache Tree.
Borders of open woods; scarce.
Woods one half mile north of Hickory Grove schoolhouse. Grant.
The flowers sometimes perfect and the pistils often six. April 15.

221. PTELEA L.

443. (2437.) P. TRIFOLIATA L. Hop Tree. Wafer Ash. Shrubby Trefoil.
Dry, gravelly or sandy banks; scarce.
Hillside, near Conover's Pond. Banks of Lost Creek, near Seventh Street Bridge. Coal Creek. May 20.

SIMARUBACEAE. Ailanthus Family.

222. AILANTHUS Desf.

444. (2438.) A. GLANDULOSA Desf. Tree of Heaven.
Roadsides, escaped from cultivation; scarce.
Lockport road, near crossing of E. & T. H. railway. April 25.

POLYGALACEAE. Milkwort Family.

223. POLYGALA L.

445.* (2451.) P. POLYGAMA Walt. Pink Polygala.
Dry, sandy soil; rare.
Side of Vandalia railway, one mile east of Terre Haute. May 16.

446.* (2454.) P. SENEGA L. Seneca Snake-root.
Prairie borders in dry soil; scarce.
Quite common at Heckland. May 8.

447. (2456.) P. VERTICILLATA L. Whorled Milkwort.
Dry, upland woods; rare.
Taken but once, October 17, 1896, in Hipple's Coal-mine Woods. In flower and fruit at that time.

448.* (2457.) P. VIRIDESCENS L. Pulple Milkwort.
(*P. sanguinea* L.)
Low, sandy soil; scarce.
Heckland. Sides of Van. Railway. Hipple's Coal-mine Woods. June 25.

EUPHORBIACEÆ. Spurge Family.

224. PHYLLANTHUS L.

449. (2460.) P. CAROLINENSIS Walt.
Sandy banks along roadsides; scarce.
North side of Fair Ground. September 30, 1889.

225. ACALYPHA L.

450. (2469.) A. VIRGINICA L. Three-seeded Mercury.
Low or sandy waste places; common. July 8 to November.

450a. (2470.) A. VIRGINICA GRACILENS (A. Gray) Muell.
Equally common and in similar localities. July 15.

226. EUPHORBIA L.

451. (2478.) E. COMMUTATA Engelm.
Damp shaded banks; scarce.
T. H. & L. Railway, north of Otter Creek Junction. Lost Creek, near Seventh Street bridge. May 25.

452. (2479.) E. COROLLATA L. Flowering Spurge. White Spurge.
Gravelly banks, especially along the railways and canals; common. May 25.

453. (2481.) E. CYPARISSIAS L. Garden Spurge. Cypress Spurge.
Roadsides and banks of railways; scarce.
Taken on two different seasons along Vandalia Railway near Fair Ground. May 28.

454. (2483.) E. DENTATA Michx. Tooth-leaved Spurge.
Shaded banks in rich sandy soil; scarce.
Old canal, between Conover's Pond and Fort Harrison. September 6.

455. (2491.) E. HETEROPHYLLA L. Diverse-leaved Spurge.
Banks of canal and hillsides near Five Mile Pond; scarce. September 1.

The first record for the State.

456. (2493.) E. HUMISTRATA Engelm.
Fields and banks in dry soil; frequent. July 10.

Much more leafy than *E. maculata* L.

457.*. (2498.) E. NUTANS Lag.
(*E. preslii* Guss.)
Borders of woods, sandy banks and hillsides; common. July 5.

Varies in height from one to four feet; in size of flower and in color of stems, the latter in older and larger specimens becoming red. The pods of this and allied species, when dry, burst open with a snapping or crackling noise and project the seeds to a distance of several feet.

458.* (2499.) E. MACULATA L. Spotted Spurge.
Open, dry or sandy banks and roadsides; common. July 2.

CALLITRICHACEÆ. Water Starwort Family.

227. CALLITRICHE L.

459. (2513.) C. HETEROPHYLLA Pursh. Water Starwort.
Ponds, ditches, etc.; frequent.
Pond at Sand Hill. Five-Mile Pond, etc. April 30.

LIMNANTHACEÆ. False Mermaid Family.

228. FLŒRKEA Willd.

46 .* (2518.) F. PROSERPINACOIDES Willd. False Mermaid.
Damp, open woods; rare.
Taken but once, May 12, 1888, in woods northwest of Ferrell's.

ANACARDIACEÆ. Cashew Family.

229. RHUS L.

461.* (2522.) R. GLABRA L. Smooth Sumach.
Dry, sandy soil and upland thickets; common. June 10.

462. (2525.) R. RADICANS L. Poison Ivy.
(*R. toxicodendron* L.)
Fence-rows and borders of thickets; common. May 27.

The low, upright form is most frequent in open, sandy soil; the high, climbing form in rich, open woods. The stems of the latter are found two and one-half inches in diameter. See No. 480 below.

AQUIFOLIACEÆ. Holly Family.

230. ILEX L.

463. (2536.) I. VERTICILLATA (L.) A. Gray. Black Alder. Winterberry.
Low, wet woods and borders of swamps; scarce.
Dense woods northwest of Hickory Grove School-house. Banks of Little Honey Creek. S. W. ¼ of S. E. ¼, Sec. 6, Pierson Twp. Heckland. May 10.

The bright, red berries are especially conspicuous in early winter when the ground is covered with snow.

CELASTRACEÆ. Staff-tree Family.

231. EUONYMUS L.

464.* (2542.) E. ATROPURPUREUS Jacq. Wahoo. Spindle Tree. Burning Bush.
Rich, open woods; frequent.
Coal Creek. Ferrell's. Sand Hill, etc. May 27.

Among the wild fruits which cater to the sense of sight rather than of taste, that of the wahoo seems to me most beautiful. Hanging on slender pedicels, four or more in a cluster, from the same peduncle, its deep scarlet color and odd shape render it a most striking object. Add to this the orange aril of its seeds, peeping so daintily through the half open suture of the pod after the latter has been touched by one or two keen frosts, and we have a combination and a contrast most pleasing to the eye.

465.* (2544) E. obovatus Nutt. Trailing Strawberry Bush.
(*E. americanus obovatus* T. and G.)
Low, damp woods and thickets; frequent.
Honey Creek. Ferrell's. Coal Creek. April 21.

232. CELASTRUS L.

466.* (2546.) C. scandens L. Waxwork. Climbing Bitter-sweet.
Borders of woods, thickets and fencerows; frequent.
Sides of canal. Sand Hill, etc. May 12.

After the first severe frost the orange-colored pods open and display the scarlet aril within. One of the most ornamental of our wild twining shrubs and easily transplanted and cultivated.

STAPHYLEACEÆ. Bladder Nut Family.

233. STAPHYLEA L.

467. (2547.) S. trifolia L. American Bladder Nut.
Hillside, thickets; frequent.
Honey Creek. Northeast of Sand Hill. Coal Creek. April 21.

ACERACEÆ. Maple Family.

234. ACER L.

468.* (2550.) A. negundo L. Box Elder. Ash-leaved Maple.
(*Negundo aceroides* Moench.)
Banks of streams and low grounds; frequent.
Honey Creek. Banks of canal, etc. April 8.

469. (2551.) A. nigrum Michx. Black Sugar Maple.
(*A. saccharinum nigrum* T. and G.)
With *A. saccharum* Marsh , but much less common. April 10.

Distinguished by the darker bark of the trunk and the form of the base and lobes of the leaves.

470. (2553.) A. rubrum L. Red Maple. Swamp Maple.
Borders of swamps and wet woods; frequent. February 16.

This is the earliest flowering woody plant found in the county, and its leaves in autumn are most beautifully colored by the first frosts. It is often palmed off as the soft maple, but is inferior to the latter for the purpose of transplanting for shade. It blooms a fortnight earlier, and the flowers are a deep pinkish-red and arranged on very short stems in little clusters near the end of the branches. Those of the soft maple are yellowish-green in color and are borne on longer stems.

471. (2554.) A. SACCHARINUM L. Soft Maple. White Maple. Silver Maple.

(*A. dasycarpum* Ehrh.)

Low, damp woods and river bottoms; common. March 10.

When properly planted and tended the soft maple is one of the most ornamental of shade trees. It is a rapid grower, easily transplanted, and, when given room, it develops into a noble and pleasing form. To allow it free access to the sun and air, with full room for expansion on every side, it should be planted not closer than thirty-five feet to one of its kind.

472. (2555.) A. SACCHARUM Marsh. Sugar Maple. Hard Maple.

(*A. saccharinum* Wang.)

Open, upland woods; common. April 15.

The hard maple is one of the most beautiful of our native forest trees; indeed, few trees of any country can equal it in stateliness of form or gracefulness of habit. No other tree supports an equally massive head of foliage on so slender a stem. No other, of equal size, is more compact in its growth; and, after reaching a height of thirty or forty feet, if the top be cut out, no other tree will assume a form more rounded or pleasing in outline, provided it be given plenty of room.

HIPPOCASTANACEÆ. Horse-chestnut Family.

235. ÆSCULUS L.

473. (2559.) A. GLABRA Willd. Ohio Buckeye.

Open woods and along streams in rich soil; frequent.

Sand Hill. Honey Creek. April 14.

BALSAMINACEÆ. Jewel-weed Family.

236. IMPATIENS L.

474. (2566.) I. AUREA Muhl. Pale Touch-me-not. Jewel-weed.

(*I. pallida* Nutt.)

Bottoms of ravines and damp, shady places; frequent.

Grant. Coal Creek. Ferrell's. June 10.

475. (2567.) I. BIFLORA Walt. Spotted Touch-me-not.

(*I. fulva* Nutt.)

With the preceding but less frequent. June 20.

RHAMNACEÆ. Buckthorn Family.

237. CEANOTHUS L.

476.* (2574.) C. AMERICANUS L. Red Root. New Jersey Tea.
Open, sandy woods and roadsides; frequent.
Sides of railway near Heckland. Hillside near Five-Mile Pond. E. & T. H. R. R., etc. May 28.

VITACEÆ. Vine Family.

238. VITIS L.

477. (2577.) V. AESTIVALIS Michx. Summer Grape.
Dry, upland thickets and fencerows; frequent, especially in the southern half of the county. May 10.
The fruit ripens about mid-September and may be readily known from that of the following by its sweet, musky taste; slightly larger size, and the compactness of the bunches.

478. (2581.) V. CORDIFOLIA Michx. Frost Grape. Chicken Grape.
Borders of streams and low ground thickets; common. April 25.

479. (2587.) V. VULPINA L. Riverside Grape.
(*V. riparia* Michx.)
Banks of streams and low ground; not common.
Honey Creek. Coal Creek. May 1.

239. PARTHENOCISSUS Planch.

(*Ampelopsis* Michx.)

480. (2588.) P. QUINQUEFOLIA (L.) Planch. Virginia Creeper. American Ivy. Five-leaved Ivy. Woodbine.
(*Ampelopsis quinquefolia* Michx.)
Open woods and fencerows; common. May 25.

One of the most handsome of our wild vines; easily cultivated; often confounded with poison ivy (*Rhus radicans* L.) from which it may readily be distinguished by its five leaflets and black fruit; the leaflets of the poison ivy being three in number and the fruit whitish-yellow.

TILIACEÆ. Linden Family.

240. TILIA L.

481.* (2592.) T. AMERICANA L. Basswood. Lin. Whitewood.
Open woods, sides of ravines, etc., in rich soil; frequent. May 24.

The fragrant flowers of the lin or basswood, abounding as they do in honey, are very attractive to bees, butterflies and other nectar-loving insects, and when the trees are in full blossom the buzz and hum of these visitors can be heard some rods away. Rare species of butterflies can then often be found in their vicinity. For example, on June 4, 1896, the writer took 18 specimens of the uncommon *Libythea bachmani* Kirtland from the flowers of three basswood trees standing in front of his residence in a thickly settled portion of the city of Indianapolis.

MALVACEÆ. Mallow Family.

241. ABUTILON Gærtn.

482. (2595.) A. ABUTILON (L.) Rusby. Velvet Leaf. Indian Mallow.

(*A. avicennæ* Gærtn.)

Cultivated fields and roadsides, especially in alluvial soil; common. June 1.

242. MALVA L.

483. (2601.) M. ROTUNDIFOLIA L. Common Mallow.

Roadsides and waste places in city; common. April 22.

The petals vary from whitish to pale blue and pinkish.

243. SIDA L.

484. (2614.) S. SPINOSA L.

Roadsides and open woods in sandy soil; common. June 3 to November.

244. HIBISCUS L.

485. (2615.) H. LASIOCARPUS Cav. Rose Mallow.

Borders of prairie swamps; scarce. July 5.

Noted in the county only at Heckland, one-third of a mile west of the station.

486.* (2616.) H. MILITARIS Cav. Halberd-leaved Rose Mallow.

Sandy overflowed bottoms of Wabash River; frequent south of Five-mile Pond and near Durkey's Ferry. July 10.

HYPERICACEÆ. St. John's-wort Family.

245. HYPERICUM L.

487. (2631.) H. DENSIFLORUM Pursh. Densely-flowered St. John's-wort.

Edge of river bank in woods below Ft. Harrison. October 12, 1896.

The first record for the State.

488. (2640.) H. MACULATUM Walt. Spotted St. John's-wort.

Low, moist ground; frequent.

Heckland. Beach's woods. June 20.

The sepals as well as petals are marked with black lines.

489. (2642.) H. MUTILUM L. Dwarf St. John's-wort.
Moist meadows and cultivated fields; common. July 1.

490. (2643.) H. PERFORATUM L. Common St. John's-wort.
Old fields, meadows and roadsides; frequent. June 1.

491. (2645.) H. PROLIFICUM L. Shrubby St. John's-wort.
Banks of streams and borders of moist, open woods; scarce.
Coal Creek. Honey Creek north of Lockport. July 3.

CISTACEÆ. Rock-Rose Family.

246. HELIANTHEMUM Pers.

492. (2654.) H. CANADENSE (L.) Michx. Frost-weed. Rock-rose.
Dry, sandy hillsides; scarce.
Hillside near Five-Mile Pond. May 28.

247. LECHEA L.

493. (2662.) L. MINOR L. Pinweed.
Margins of prairies, etc., in dry soil; scarce.
Near Five-mile Pond, on hillside. Heckland. July 25 to November 1.

VIOLACEÆ. Violet Family.

248. VIOLA L.

494. (2667.) V. BLANDA Willd. Sweet White Violet.
Damp wooded hillsides; rare.
Woods east of St. Mary's. April 28.

495.* (2675.) V. LANCEOLATA L. Lance-leaved Violet.
Margins of ponds and damp prairies; scarce.
Goose Pond. Heckland. April 16.

496. (2678.) V. OBLIQUA Hill. Common Blue Violet.
(*V. palmata cucullata* Gray.)
Moist, low grounds; abundant. April 5 to November.

497. (2680.) V. PALMATA L. Blue Violet.
Dry open woods; scarce.
Sand Hill. Beach's woods. April 20.

498. (2684.) V. PEDATAFIDA Don.
Dry, sandy places; rare.
Collected by Mr. U. O. Cox, near Five-mile Pond. May 4, 1891.

499. (2686.) V. PUBESCENS Ait. Downy Yellow Violet.
Dry, open woods; common. April 13.

500. (2689.) V. SAGITTATA Ait. Arrow-leaved Violet.
Borders of moist prairies; scarce.
Heckland. April 28.

501. (2694.) V. STRIATA Ait. Pale Violet.
Open woods in sandy soil; common. April 13.

The petals vary in color from deep cream to almost white.

502. (2695.) V. TENELLA Muhl. Wild Pansy. Heart's Ease.
(*V. tricolor arvensis* L.)
Dry, sandy banks; frequent. March 17.
Beach's woods. Southeast of Hunt's Rosary.

249. SOLEA Spreng.

503. (2698.) S. CONCOLOR (Forst.) Gingins. Green Violet.
Damp, wooded hillsides; scarce. April 21.
Honey Creek. Coal Creek.

PASSIFLORACEÆ. Passion Flower Family.

250. PASSIFLORA L.

504. (2701.) P. LUTEA L. Northern Passion Flower.
Borders of open woods in rich soil; scarce.
Taken but once, September 19, 1889, from McKeen's woods south of Fair Ground.

THYMELAEACEÆ. Mezereum Family.

251. DIRCA L.

505. (2714.) D. PALUSTRIS L. Leatherwood. Moosewood.
Rich hillside thickets and banks of streams; scarce.
Grant. Coal Creek. April 14.

LYTHRACEÆ. Loosestrife Family.

252. ROTALA L.

506.* (2718.) R. RAMOSIOR (L.) Kœhne.
Ditches and mucky borders of ponds; scarce.
Marshes south of Fair Ground. Conover's Pond. August 21.

253. AMMANNIA L.

507.* (2720.) A. COCCINEA Rottb. Ammannia.
Low, damp places; frequent.
Heckland. Marsh south of Fair Ground. August 10 to October 20.

254. LYTHRUM L.

508.* (2723.) L. ALATUM Pursh. Loosestrife.
Margins of wet prairies; scarce.
Heckland. June 12.

255. DECODON J. F. Gmel.

509. (2729) D. VERTICILLATUS (L) Ell. Swamp Loosestrife.
Borders of marshes; rare.
Near Heckland.

ÓNAGRACEÆ. Evening Primrose Family.

256. LUDWIGIA L.

510. (2736.) L. ALTERNIFOLIA L. Seed-box.
Ditches and margins of swamps; scarce.
Side of Vandalia Railway, near Glen. Goose Pond. July 10.
Variable; the petals sometimes smaller than the sepals.

511. (2742.) L. PALUSTRIS (L.) Ell. Water Purslane.
Ditches and muddy brooks; frequent.
Side of Vandalia Railway, near Glen. Outlet of Five-mile Pond, etc. July 12.

512. (2743.) L. POLYCARPA Short and Peter. False Loosestrife.
Swamps and margins of ponds; scarce.
Marsh near Vandalia Railway, west of Beach's woods, and farther east near Glen. September 6, 1889.

257. EPILOBIUM L.

513.* (2747.) E. COLORATUM Muhl. Willow Herb.
Low damp soil; common. July 5.

514.* (2752.) E. STRICTUM Muhl. Downy Willow Herb.
Borders of swamps; rare.
Taken but once, October 6, 1889, from marsh near Vandalia Railway, west of Beach's woods.

258. ONAGRA Adans.
(*Œnothera* L. in part.)

515. (2756.) O. BIENNIS (L.) Scop. Evening Primrose.
(*Œnothera biennis* L.)
Borders of fields and waste places, especially in sandy soil; common. June 25 to October 16.

259. ŒNOTHERA L.

516. (2761.) O. SINUATA L. Sinuate-leaved Primose.
Sandy cultivated fields; scarce.
Probably a railroad migrant from the South. May 14.
The first record for the State.

260. KNEIFFIA Spach.

517.* (2765.) K. FRUITICOSA (L.) Raimann. Sun-drops.
(*Œnothera fruiticosa* L.)
Dry prairies; frequent.
Heckland. T. H. & L. R. R. Hillside near Five-mile Pond. June 8.

261. GAURA L.

518.* (2782.) G. BIENNIS L.
Sandy soil in waste places; frequent.
Canal, near Five-mile Pond. Along railways. June 27.

262. CIRCÆA L.

519. (2790.) C. LUTETIANA L. Enchanter's Nightshade.
Open woods in rich soil; common. June 23.

HALORRHAGIDACEÆ. Water Milfoil Family.

263. MYRIOPHYLLUM L.

520. (2804.) M. VERTICILLATUM L. Water Milfoil.
Ponds; scarce.
Goose Pond. Five-Mile Pond. May 2.
The first record for the State.

ARALIACEÆ. Ginseng Family.

264. ARALIA L.

521. (2808.) A. RACEMOSA L. Spikenard.
Sides of deep, damp ravines; scarce.
Coal Creek. Grant. June 28.

265. PANAX L.

522. (2810.) P. QUINQUEFOLIUM L. Ginseng.
(*Aralia quinquefolia* Dec. and Planch.)
Rich wooded hillsides and ravines; scarce.
Honey Creek. Grant. Coal Creek. May 5.

Once a noted article of commerce, the spicy roots being gathered in large quantities for shipment to China.

UMBELLIFERÆ. Parsley Family.

266. DAUCUS L.

523. (2812.) D. CAROTA L. Wild Carrot.
Old fields and roadsides; frequent. June 20.
Spreading rapidly and fast becoming a nuisance.

267 OXYPOLIS Raf.
(*Tiedemannia* DC.)

524. (2820.) O. RIGIDUS (L.) Britton. Cowbane.
(*Tiedemannia rigida* DC.)

Borders of swamps; scarce.
Heckland. Goose Pond. July 18.

268. HERACLEUM L.

525. (2822.) H. LANATUM Michx. Cow Parsnip.
Low, damp places; scarce.
Marsh near Glen. June 1.

269. PASTINACA L.

526. (2823.) P. SATIVA L. Wild Parsnip.
Waste places, especially in moist soil; frequent.
Sides of Van. Railway near Glen. Roadsides near Sand Hill. May 28.

270. THASPIUM Nutt.

527. (2831.) T. BARBINODE (Michx.) Nutt. Meadow Parsnip.
Rich or sandy soil; scarce.
Old canal south of Conover's Pond. June 16.

528.* (2834.) T. TRIFOLIATUM (L.) Britton.
Open woods in rich, dry soil; frequent.
McKeen's Woods. Banks of canal near Ft. Harrison, etc.

528a. (2835.) T. TRIFOLIATUM AUREUM (Nutt.) Britton. Meadow Parsnip.
(*T. aureum* Nutt.)
Sides of ditches and upland swamps; frequent.
Heckland. Van. Railway, etc. May 8.

271. ERYNGIUM L.

529.* (2842.) E. AQUATICUM L. Rattlesnake-master. Button Snake-root.

(*E. yuccæfolium* Michx.)

Borders of prairies.

Common at Heckland and along the T. H. & L. Railway above Otter Creek Junction. July 16.

272. SANICULA L.

530. (2846) S. CANADENSIS L. Black Snake-root.

(*S. marylandica canadensis* Torr.)

Thickets and open woods; frequent. May 12.

531. (2847.) S. MARYLANDICA L. Sanicle. Black Snake-root.

Rich, rather damp woods; scarce.

Beach's. Woods east of St. Mary's. May 16.

273. EULOPHUS Nutt.

532. (2855.) E. AMERICANUS Nutt.

Borders of prairies, rare.

Heckland. October 5, 1889.

Recorded hitherto only from Gibson County.

274. CHÆROPHYLLUM L.

533.* (2858.) C. PROCUMBENS (L.) Crantz. Chervil.

Open woods in rich, sandy soil; scarce.

Sand Hill. May 2.

275. OSMORRHIZA Raf.

534. (2860.) O. CLAYTONI (Michx.) B. S. P. Hairy Sweet Cicely.

(*O. brevistylis* DC.)

Damp, rich woods; frequent. May 11.

535. (2861.) O. LONGISTYLIS (Torr.) DC. Smooth Sweet Cicely.

Thickets and fence-rows; less frequent than the above. May 6.

276. SIUM L.

536. (2864.) S. CICUTÆFOLIUM J. F. Gmel. Water Parsnip.

Ditches and borders of ponds; frequent. July 10.

Pond at Sand Hill. Heckland. Van. Railway.

277. CICUTA L.

537.* (2874.) C. MACULATA L. Spotted Cowbane. Musquash Root. Beaver Poison.

Marshes and ditches; common. July 11.

278. DERINGA Adans.

(*Cryptotænia* DC.)

538. (2875.) D. CANADENSIS (L.) Kuntze. Honewort.
(*Cryptotænia canadensis* DC.)
Borders of thickets and rich woods; frequent.
Ferrel's. Southeast of Hunt's. Honey Creek. June 2.

279. ERIGENIA Nutt.

539.* (2887.) E. BULBOSA Nutt. Harbinger of Spring. Pepper and Salt. Turkey Pea.
Open woods, especially in damp, rich soil; common. February 23.

CORNACEÆ. Dogwood Family.

280. CORNUS L.

540. (2889.) C. ALTERNIFOLIA L. f. Alternate-leaved Dogwood.
Sides of ravines and upland fencerows; frequent. May 12.

541. (2893.) C. CANDIDISSIMA Marsh. Panicled Cornel or Dogwood.
(*C. paniculata* L'Her.)
Dry, open hillsides and borders of thickets; frequent.
East of Five-mile Pond. Heckland. Glen. May 20.

This species has the leaves smaller and more crowded than those of any other in our bounds.

542.* (2894.) C. CIRCINATA L'Her. Round-leaved Dogwood.
Borders of open, rich woods and thickets; rare.
Ferrell's. Southeast ¼ section 6, Pierson Tp. May 8.

Recorded before only from Lake County.

543. (2895.) C. FLORIDA L. Flowering Dogwood.
Borders of open woods in dry soil; common. April 20.

544. (2896.) C. STOLONIFERA Michx. Red Osier Dogwood.
Borders of thickets and gravelly banks; frequent. May 11.

Contrary to the habitat usually given this species, in Vigo County, occurs as frequently in dry, gravelly soil as in damp places. It often produces a second set of blossoms the same year; a clump growing in the bed of the old canal near Conover's Pond being in bloom on October 14, 1896.

281. NYSSA L.

545. (2899.) N. AQUATICA L. Black Gum. Sour Gum.
(*N. sylvatica* Marsh.)
Open, rather damp, upland woods; frequent. May 17.

Reaches a large size in the southern part of the county, but is put to no use on account of the difficulty of working the wood. The foliage is very handsome after the first frosts of autumn.

MONOTROPACEÆ. Indian-Pipe Family.

282. MONOTROPA L.

546. (2918.) M. UNIFLORA L. Indian Pipe. Corpse Plant.
Dry wooded hillsides, in rich soil; scarce.
Coal Creek hills. Hipple's Coal-mine woods. July 1 to October 24.

283. HYPOPITYS Adans.

547. (2919.) H. HYPOPITYS (L.) Small. Pine-sap. False Beech-drops.
(*Monotropa hypopitys* L.)
Found but once, October 24, 1896, in dry woods at Coal Creek.
Flowers about the last of June.

PRIMULACEÆ. Primrose Family.

284. SAMOLUS L.

548. (2995.) S. FLORIBUNDUS HBK. Brookweed. Water Pimpernel.
(*S valerandi americanus* Gray.)
Damp, shaded places; scarce.
Sand Hill, near spring. Vandalia Railway, near Beach's. June 14.

285. STEIRONEMA Raf.

549.* (3001.) S. CILIATUM (L.) Baudo. Loosestrife.
Borders of low, damp prairies and streams; scarce.
Heckland. Honey Creek. June 20.

550. (3003.) S. LANCEOLATUM (Walt.) A. Gray.
Borders of damp thickets and ditches; frequent.
Marsh south of Van. Railway, near Glen. Ferrell's. June 12.

551. (3004.) S. QUADRIFLORUM (Sims) A. S. Hitchc.
(*S. longifolium* Gray.)
Banks of streams, fence rows, etc.; frequent.
Coal Creek. Grant. July 1.

EBENACEÆ Ebony Family.

286. DIOSPYROS L.

552. (3018.) D. VIRGINIANA L. Persimmon. Date Plum.
Old fields and fence rows; frequent, especially in southern half of the county, where it is indigenous. June 1.
The fruit varies much in size, date of ripening and quality.

OLEACEÆ. Olive Family.

287. FRAXINUS L.

553. (3025.) F. AMERICANA L. White Ash.
Open woods; common. April 20.

554. (3028.) F. LANCEOLATA Borck. Green Ash.
(*F. viridis* Michx. f.)
Low rich bottoms along streams; frequent.
Honey Creek. Sugar Creek. Near Ft. Harrison. May 1.

555. (3029.) F. NIGRA Marsh. Black Ash.
(*F. sambucifolia* Lam.)
Borders of swamps and marshes; scarce.
Marsh northeast of Sand Hill. Goose Pond. April 15.

556. (3031.) F. QUADRANGULATA Michx. Blue Ash.
Bottoms of Wabash River and low ground generally; frequent. April 20.

In its greatest development it reaches a height of 120 feet, and measures fifteen feet in circumference two feet above the ground.

GENTIANACEÆ. Gentian Family.

288. GENTIANA L.

557.* (3057.) G. ANDREWSII Griseb. Closed Blue Gentian. Cloistered Heart.
Low grassy banks along streams; frequent.
Honey Creek. Coal Creek, etc. September 18.

557a.* (3058.) G. ANDREWSII ALBIFLORA Britton. White Gentian.
(*G. alba* Muhl.)
Dry sandy hillside southeast of Five-mile Pond; rare. September 23, 1888.

558.* (3066.) G. QUINQUEFOLIA L. Five-flowered Gentian.
(*G. quinqueflora* Lam.)
Moist hillside thickets. Noted only at Coal Creek, where it is locally common. September 5.

559.* (3070.) G. SAPONARIA L. Soapwort Gentian.
Borders of prairies; scarce.
Heckland. Van. Railway. September 15.

289. FRASERA Walt.

560. (3076.) F. CAROLINENSIS Walt. American Columbo.
Dry woods in rich soil; scarce.
Beach's woods. Woods east side of Goose Pond. Heckland. May 27.

290. OBOLARIA L.

561. (3079.) O. VIRGINICA L.

Rare. Noted only at Coal Creek in dry woods. April 1, 1890.

Prof. Evermann found three plants at same place on January 26, 1890. He brought them home and they bloomed on February 11.

Recorded in Indiana only from Jefferson County, but has also been taken by the writer in Monroe.

APOCYNACEÆ. Dogbane Family.

291. APOCYNUM L.

562. (3087.) A. ANDROSÆMIFOLIUM L. Spreading Dogbane.
Borders of thickets, banks, etc., in dry soil; scarce.
Honey Creek. Grant. June 20.

563. (3088.) A. CANNABINUM L. Indian Hemp.
Borders of streams and moist prairies; frequent. June 1.

ASCLEPIADACEÆ. Milkweed Family.

292. ASCLEPIAS L.

564. (3097.) A. INCARNATA L. Swamp Milkweed.
Borders of swamps and marshes; common. July 4.

565.* (3102.) A. OBTUSIFOLIA Michx. Obtuse-leaved Milkweed.
Gravelly banks; frequent.
Van. Railway. E. & T. H. Railway near Spring Hill. May 25.

566. (——). A. PHYTOLACCOIDES Pursh. Poke Milkweed.
Borders of moist thickets and sides of ravines; rare.
Thicket west of Macksville near Broadhurst Mine. May 31.

567.* (3106.) A. PURPURASCENS L. Purple Milkweed.
Borders of dry, sandy fields; scarce.
One mile southeast of Prairieton. Van. Railway west of Glen. June 14.

568. (3107.) A. QUADRIFOLIA Jacq. Four-leaved Milkweed.
Wooded hillsides and thickets; scarce.
Coal Creek. Hipple's Coal-mine woods. June 1.

569. (3111.) A. SYRIACA L. Common Milkweed. Silkweed.
(*A. cornuti* Dec.)
Waste places in rich soil; common. June 2.

570.* (3112.) A TUBEROSA L. Butterfly Weed. Pleurisy Root. Indian Posey.
Sandy soil and gravelly banks; frequent. June 15.
Along railways and old canal.

571. (3113.) A. **VARIEGATA** L. Variegated Milkweed.
Dry woods; scarce. June 14.
Beach's Woods. Van. Railway near Glen.

572. (3114.) A. **VERTICILLATA** L. Whorled Milkweed.
Sandy hillside near Five-Mile Pond; frequent in the one place. July 6.
Not before recorded in Indiana south of Tippecanoe County.

293. AMPELANUS Raf.
(*Enslenia* Nutt.)

573. (3124.) A. **ALBIDUS** (Nutt.) Britton. Climbing Milkweed.
(*Enslenia albida* Nutt.)
One specimen taken north of Fort Harrison, near bank of Wabash River. September 21, 1896.
Its most northern record for the State.

CONVOLVULACEÆ. Convolvulus Family.

294. IPOMŒA L.

574. (3135.) I. **HEDERACEA** Jacq.
Alluvial bottom lands; scarce.
Wabash bottoms below Ft. Harrison. Canal, near Five-mile Pond. September 10.

575. (3136.) I. **LACUNOSA** L. Wild Morning Glory.
Alluvial soil and sand bars along the Wabash River; frequent. August 20.

576 (3138.) I. **PANDURATA** (L.) Meyer. Wild Sweet Potato. Man-of-the-Earth.
Sandy cultivated fields; frequent or common. June 20.

577. (3139.) I. **PURPUREA** (L.) Roth. Common Morning Glory.
Gravelly banks and roadsides; frequent, especially along the railways. September 1.

295. CONVOLVULUS L.

578. (3145.) C. **ARVENSIS** L. Bindweed.
Old fields and roadsides; scarce. June 11.

579. (3148.) C. **SEPIUM** L. Bracted Bindweed. Hedge Bindweed,
Gravelly banks and borders of wet fields; frequent. June 6.

CUSCUTACEÆ. Dodder Family.

296. CUSCUTA L.

580. (3161.) C. GRONOVII Willd. Dodder.
Borders of marshes and damp thickets; common. July 15.

581. (3163.) C. POLYGONORUM Engelm. Dodder.
(*C. chlorocarpa* Engelm.)
Low, damp soil, on *Solidago rugosa* Mill. and *Ambrosia trifida* L.; frequent. July 25.

The dodder is among the most interesting of our parasitic plants. It is a parasite by suicide. That is, it springs from a seed which furnishes it nourishment until it finds some suitable host around which it coils itself. In coiling it contracts, and so pulls itself up by the roots. If not uprooted a portion of the stem a few inches above the soil withers, dies and breaks apart, while the upper, twining portion continues to flourish throughout the season.

If one could trace its history from the beginning he would doubtless find that it once possessed a weak stem, and desiring to reach the light, and twining to accomplish this, it tasted juices by chance, was nourished by them, and thus began a downfall which has continued until it presents the degraded spectacle of a plant "without a root, without a twig, without a leaf, and having a stem so useless as to be inadequate to bear its own weight. Other plants, with smaller beginnings, have gone on to higher forms, while the dodder, from a breach of the laws of evolution, pays one of nature's heaviest fines—loses the organs which it once possessed."

POLEMONIACEÆ. Polemonium Family.

297. PHLOX L.

582.* (3166) P. BIFIDA Beck. Dwarf Phlox.
Sandy hillsides and dry, open woods.
Common at Five-mile Pond and Coal Creek. April 7.

583. (3168.) P. DIVARICATA L.
Open woods and ravines; common. April 5.

Variable. Leaves sometimes alternate and very hairy; in form from ovate to lanceolate. Petals notched at apex or entire; in color from purplish to white.

584.* (3172.) P. GLABERRIMA L. Smooth-stemmed Phlox.
Moist banks and prairies; scarce.
Heckland. Vandalia Railway, near Glen. May 25.

Its most northern record for Indiana.

585. (3173.) P. MACULATA L. Wild Sweet William.
Borders of prairies and damp woods; scarce.
Heckland. Ferrell's. June 1.

586.* (3175.) P. PANICULATA L. Panicled Sweet William.
Rich, shaded grounds, usually near streams; frequent.
Honey Creek. Vandalia Railway, near Beach's, etc. June 5.

587.* (3176.) P. PILOSA L. Hairy Phlox.
Damp prairies and borders of woods; scarce.
Heckland. Ferrell's. May 12.

298. POLEMONIUM L.

588. (3192.) P. REPTANS L. Greek Valerian.
Rich wooded slopes and ravines; common. April 13.

All specimens noted were more or less hairy.

HYDROPHYLLACEÆ. Waterleaf Family.

299. HYDROPHYLLUM L.

589. (3196.) H. APPENDICULATUM Michx.
Open woods and ravines; common. April 20.

Often but one ovule is formed in the ovary. The lobes in the sinuses of the calyx vary much in size.

590. (3197.) H. CANADENSE L. Canada Waterleaf.
Sides of deep, damp ravines; scarce.
Honey Creek. Coal Creek. Heckland. May 7.

591.* (3198.) H. MACROPHYLLUM Nutt. Hairy Waterleaf.
Rich, damp woods, ravines, etc.; scarce.
Southeast of Hunt's. Ferrell's. Beach's. May 1.

592.* (3199.) H. VIRGINICUM L. Virginia Waterleaf.
Ravines and open woods in damp soil; frequent. May 8.

300. MACROCALYX Trew.

(*Ellisia* L.)

593.* (3201.) M. NYCTELEA (L.) Kuntze. Ellisia.
(*Ellisia nyctelea* L.)
Noted only in a damp spot on hillside at North Sand Hill. May 25
Identified as *E. ambigua* Nutt., now included with the above.

The first record for the State.

301. PHACELIA Juss.

594. (3202.) P. BIPINNATIFIDA Michx. Phacelia.
Wooded slopes in rich soil; scarce. April 28.
Coal Creek. Honey Creek.

The scarcity of this species suggests that Vigo County is near the northern limit of its range in Indiana. In Monroe County it is very common.

595.* (3210.) P. PURSHII Buckl. Pursh's Phacelia.
Sandy open woods; frequent. April 28.
Sand Hill. Coal Creek. Heckland, etc.

BORAGINACEÆ. Borage Family.

302. HELIOTROPIUM L.

596. (3217.) H. INDICUM L Indian Heliotrope.
Banks of Wabash near Ft. Harrison; scarce. July 1.

303. CYNOGLOSSUM L.

597. (3219.) C. OFFICINALE L. Common Hound's Tongue.
Old fields and roadsides; common. May 20.

598. (3220.) C. VIRGINICUM L. Wild Comfrey.
Dry wooded hillsides; scarce.
Coal Creek Hills. Hipple's Coal-mine woods. May 26.

304. LAPPULA Moench.

(*Echinospermum* Lehm.)

599. (3223.) L. LAPPULA (L.) Karst. Stickseed.
(*Echinospermum lappula* Lehm.)
Open waste places; scarce.
Along Vandalia Railway near Fair Ground. June 29.

600. (3225.) L. VIRGINIANA (L.) Greene. Beggar's Lice. Stickseed. Sticktight.
(*Echinospermum virginicum* Lehm.)
Open woods, borders of thickets and fence-rows; common. July 3.

305. MERTENSIA Roth.

601. (3236.) M. VIRGINICA (L.) DC. Blue Bells. Smooth Lungwort. Virginia Cowslip.
Damp, open woods and banks of streams; frequent.
Near Lost Creek Bridge on Seventh Street road. McKeen's woods, etc. April 5.

306. MYOSOTIS L.

602. (3241.) M. **PALUSTRIS** (L.) Relh. Forget-me-not.
Damp, low places; scarce.
Spring branch south side of National road near Highland Lawn; escaped. May 20.

307. LITHOSPERMUM L.

603. (3244.) L. **ARVENSE** L. Corn Gromwell.
Waste sandy places along railways and canal; scarce. April 25.

604.* (3245.) L. **ANGUSTIFOLIUM** Michx. Narrow-leaved Puccoon.
Sandy, waste places; scarce.
Side of canal and hillside near Five-mile Pond.

605.* (3246.) L. **CANESCENS** (Michx.) Lehm. Hoary Puccoon. Alkanet.
Sandy soil along the old canal; frequent. May 5.

606.* (3247.) L. **GMELINI** (Michx.) A. S. Hitchc. Hairy Puccoon.
(*L. hirtum* Lehm.)
With the preceding; common. May 10.

607. (3248.) L. **LATIFOLIUM** Michx. Broad-leaved Gromwell.
Dry, wooded hillsides; scarce.
Coal Creek. May 5

308. ONOSMODIUM Michx.

608.* (3251.) O. **CAROLINIANUM** (Lam.) A. DC. False Gromwell.
Gravelly banks along the old canal; frequent. May 22.

VERBENACEÆ. Vervain Family.

309. VERBENA L.

609. (3260.) V. **BRACTEOSA** Michx. Prostrate Vervain.
Gravelly banks and waste, sandy places; common. May 27.

610. (3261.) V. **CANADENSIS** (L.) Britton. Canada Vervain.
(*V. aubletia L.*)
Prairies and borders of railways; scarce.
Heckland. May 20.

611. (3262.) V. **HASTATA** L. Blue Vervain.
Dry banks, roadsides, etc.; frequent. June 10.

612. (3265.) V. **STRICTA** Vent. Hoary Vervain.
Waste places in dry, sandy soil; common. June 15.

613. (3266.) V. URTICÆFOLIA L. White Vervain. Nettle-leaved Vervain.
Borders of fields and roadsides in dry soil; common. June 16.

310. LIPPIA L.

614. (3269.) L. LANCEOLATA Michx. Fog-fruit.
Low, wet meadows and borders of ponds; frequent. July 20.

311. PHRYMA L.

615. (3271.) P. LEPTOSTACHYA L. Lopseed.
Moist, dense woods; common. June 19.

LABIATÆ. Mint Family.

312. COLLINSONIA L.

616. (3272.) C. CANADENSIS L. Stone Root. Richweed. Horse-Balm.
Rich soil, along wooded hillsides or ravines; frequent. July 2.

The leaves are oftentimes one foot in length; the odor strong, but rather agreeable.

313. MENTHA L.

617. (3279.) M. CANADENSIS L. Wild Mint.
Moist grounds about springs and brooks; frequent. June 18.

618. (3284.) M. PIPERITA L. Peppermint.
Borders of brooks; common. July 1.

619. (3287.) M. SPICATA L. Spearmint.
(*M. viridis* L.)
Low, wet places; frequent. July 8.

314. LYCOPUS L.

620. (3292.) L. SINUATUS Ell. Water Horehound.
Along ditches and margins of ponds; common. June 18.

621. (3293.) L. VIRGINICUS L. Bugle-weed.
Borders of swamps and wet banks; frequent. May 22.

315. KŒLLIA Moench.

(*Pycnanthemum* Michx.)

622.* (3298.) K. FLEXUOSA (Walt.) McM. Narrow-leaved Mountain Mint.
(*Pycnanthemum linifolium* Pursh.)
Dry, sandy soil; scarce.
Heckland. August 5.

623.* (3303) K. PILOSA (Nutt.) Britton. Basil.
(*Pycnanthemum muticum pilosum* Gray.)
Sandy hillsides and prairies; frequent.
Five-mile Pond. Heckland. August 27.

624.* (3306.) K. VIRGINIANA (L.) McM. Mountain Mint.
(*Pycnanthemum lanceolatum* Pursh.)
Prairies and dry, sandy woods; frequent.
Heckland. Five-mile Pond. June 28.

316. HEDEOMA Pers.

625. (3313.) H. PULEGIOIDES (L.) Pers. American Pennyroyal.
Fence-rows, open woods and roadsides in dry soil; common. June 7.

317. MONARDA L.

626.* (3333.) M. FISTULOSA L. Wild Bergamont. Horse Mint.
Dry, sandy hillsides; frequent. June 18.

627. (3336.) M. SCABRA Beck.
(*M. fistulosa mollis* Benth.)
Found in one locality along Vandalia Railway near Beach's woods. July 1, 1891.

318. BLEPHILIA Raf.

628. (3337.) B. CILIATA (L.) Raf.
Open woods; frequent. June 16.

629. (3338.) B. HIRSUTA (Pursh.) Torr.
Dense, moist woods; common. June 20.

319. VLECKIA Raf.

(*Lophanthus* Benth.)

630. (3340.) V. NEPETOIDES (L.) Raf. Giant Hyssop.
(*Lophanthus nepetoides* Benth.)
Borders of thickets and fence-rows; frequent. September 5.

631. (3341.) V. SCROPHULARIÆFOLIA (Willd.) Raf.
(*Lophanthus scrophulariæfolius* Benth.)
Fence rows in rich, dry upland soil; scarce.
East side of South Sand Hill woods. September 30.

320. NEPETA L.

632. (3342.) N. CATARIA L. Catnip.
Roadsides and fencerows; common. June 11.

321. GLECOMA L.

633. (3343.) G. **HEDERACEA** L. Ground Ivy. Gill.
(*Nepeta glechoma* Benth.)
Moist, open, grassy banks; common. April 14.

322. SCUTELLARIA L.

634. (3349.) S. **CORDIFOLIA** Muhl. Parti-colored Skullcap.
(*S versicolor* Nutt)
Wooded banks along streams; frequent. June 4.

635. (3352.) S. **INCANA** Muhl. Hoary Skullcap.
(*S. canescens* Nutt.)
Damp, open woods; frequent. June 8.

636. (3354.) S. **LATERIFLORA** L. Mad dog Skullcap.
Borders of moist thickets; common. June 11.

637. (3355.) S. **NERVOSA** Pursh.
Low, moist places in dense woods; scarce.
Ferrell's. Heckland. May 24.

323. BRUNELLA L.

638. (3363.) B. **VULGARIS** L. Self-heal. Heal-all.
Dry banks and fence-rows; common. June 5.

324. PHYSOSTEGIA Benth.

639. (3367.) P. **VIRGINIANA** (L.) Benth. False Dragonhead.
Low, damp places along the old canal; frequent. August 30.

325. SYNANDRA Nutt.

640. (3368.) S. **HISPIDULA** (Michx.) Britton. Large flowered Mint.
(*S. grandiflora* Nutt.)
Open, rich woods; scarce.
McKeen's woods, south of Fair Ground. May 25.

Our most handsome member of the Labiatæ.

Found as far north as Wabash County, though its range is given in the Barnes & Coulter Flora as "Banks of the Ohio and its tributaries."

326. STACHYS L.

641. (3372.) S. **ASPERA** Michx. Hedge Nettle.
Moist places along the banks of canal; frequent. July 2.

641a. (3372a.) S. **ASPERA GLABRA** Gray.
Wet waste places; scarce.
Five-mile Pond. July 11.

642.* (3373.) S. CORDATA Riddell. Heart-leaved Hedge Nettle.
Borders of damp upland thickets; scarce.
Ferrell's. Conover's Pond. July 14.

326a. LEONURUS L.

643. (3380.) L. CARDIACA L. Motherwort.
Waste places and fence rows; frequent. May 24.

327. TRICHOSTEMA L.

644. (3389.) T. DICHOTOMUM L. Blue Curls. Bastard Pennyroyal.
Sandy soil on river banks; scarce. Discovered by Prof. Evermann, September 1, 1889.

The first record for the State.

328. TEUCRIUM L.

645. (3392.) T. CANADENSE L. American Germander. Wood Sage.
Banks of streams and moist ground in rich soil; frequent. June 24.

SOLANACEÆ. Nightshade Family.

329. LYCIUM L.

646. (3396.) L. VULGARE (Ait. f.) Dunal. Matrimony Vine.
Waste grounds in Terre Haute; scarce. (*Evermann.*) June 10.

330. PHYSALIS L.

647.* (3405.) P. LANCEOLATA Michx. Lance-leaved Ground Cherry.
Frequent along the canal and river banks. May 21.

648. (3410.) P. PHILADELPHICA Lam. Philadelphia Ground Cherry.
Borders of cultivated fields in loose, rich soil; scarce.
Near Five-mile Pond. North side of Vandalia Railway, near Glen. May 25.

649.* (3411.) P. PUBESCENS L. Hairy Ground Cherry.
Low, waste grounds; common. May 31.

650.* (3412.) P. VIRGINIANA Mill. Virginia Ground Cherry.
Loose, sandy soil; frequent. May 25.

331. SOLANUM L.

651.* (3414.) S. CAROLINENSE L. Horse Nettle. Bull Nettle.
Roadsides and waste places in dry, sandy soil; common. June 15.

Increasing in numbers each year and bids fair to become one among the worst of weeds.

652. (3418.) S. NIGRUM L. Common Nightshade.
Shady, waste grounds; common. July 10.

653.* (3419.) S. ROSTRATUM Dunal. Texas Nettle.

Several flowering plants of this species were discovered in full bloom in a low, sandy field south of Conover's Pond, on October 22, 1888. Undoubtedly a railroad migrant. According to Prof. B. D. Halstead (Bot. Gaz., April, 1889), this is one of the thirty-four worst weeds in the United States, and is rapidly spreading eastward from its original home on the plains of Nebraska and Texas.

Recorded before in Indiana only from Tolleston, Lake County.

332. DATURA L.

654. (3424.) D. STRAMONIUM L. Jimson Weed. Thorn Apple.
Rich, waste soil; common. June 10.

655. (3425.) D. TATULA L. Purple Jimson.
Waste, sandy soil; common. June 14.

Like the burdock (*Arctium lappa* L.), these two plants delight in the waste grounds about unused barnyards and deserted dwellings, oftentimes growing so thickly in such places that one can scarcely force his way between them.

SCROPHULARIACEÆ. Figwort Family.

333. VERBASCUM L.

656. (3430.) V. BLATTARIA L. Moth Mullein.
Roadsides and waste places; scarce.

National road west of Macksville. Durkey's Ferry road, north of Five-mile Pond. May 25.

657. (3432.) V. THAPSUS L. Common Mullein.
Old, dry fields, banks and roadsides; common. June 11.

Many plants there are which man in his ignorance calls "homely weeds," ne'er seeing their smaller points of usefulness or beauty. The mullein, with its long spikes of yellow flowers and thick, velvety leaves, is one of these. Its basal leaves which, when it blooms, are withered and dry, the winter before formed a beautiful rosette close to the ground and gave shelter and protection to many an insect, both beneficial and injurious. On one occasion, in January, the writer found snugly ensconced beneath and between the leaves of a single mullein plant, four cutworms, seven chinch bugs and three tarnished plant bugs, besides a number of others less injurious—enough to have produced ten thousand of their kind the next season.

334. LINARIA Juss.

658. (3438.) L. **LINARIA** (L.) Karst. Butter and Eggs. Toad Flax. Ramsted.

(*L. vulgaris* Mill.)

Borders of fields and roadsides; frequent. June 1.

335. COLLINSIA Nutt.

659. (3442.) C. **VERNA** Nutt. Collinsia. Innocence.
Moist, shaded banks and hillsides; scarce.
Southeast of Hunt's. North Sand Hill. Honey Creek. April 13.

336. SCROPHULARIA L.

660. (3444). S. **MARYLANDICA** L. Figwort.
(*S. nodosa marylandica* Gray.)
Borders of damp thickets, fencerows, etc.; common. June 1 to October 15.
Varies much in height and date of flowering.

337. CHELONE L.

661. (3445.) C. **GLABRA** L. Turtle-head. Snake-head
Low, wet woods; scarce.
Northeast of Sand Hill. Conover's Pond. July 16

338. PENSTEMON Soland.

662.* (3453.) P. **DIGITALIS** (Sweet) Nutt.
(*P. lævigatus digitalis* Gray.)
Moist, rich soil; frequent.
Goose Pond. Five-mile Pond. June 7.

663. (3458.) P. **HIRSUTUS** (L.) Willd.
(*P. pubescens* Soland.)
Gravelly banks and borders of prairies; frequent.
Van. Railway opposite Beach's. Heckland, etc. May 16.

339. MIMULUS L.

664. (3462.) M. **ALATUS** Soland. Winged Monkey-flower.
Borders of ditches and swamps; scarce.
Five-mile Pond. August 10.

665.* (3466.) M. **RINGENS** L. Monkey-flower.
In similar locations; frequent. July 5.

340. GRATIOLA L.

666. (3469.) G. sphærocarpa Ell. Hedge Hyssop.
Low, wet places; scarce.
Marsh southwest of Fair Ground. Goose Pond. April 30.

667. (3470.) G. virginiana L. Hedge Hyssop.
Borders of ponds and ditches; frequent. May 16.

341. CONOBEA Aubl.

668.* (3472.) C. multifida (Michx.) Benth.
Sandy places along streams and borders of ponds; scarce.
Conover's Pond. Low ground near river, southwest of Terre Haute. July 20.
The leaves often whorled.

342. ILYSANTHES Raf.

669.* (3480.) I. gratioloides (L.) Benth. False Pimpernel.
(*I. riparia* Raf.)
Mucky margins of ponds and streams; frequent. June 25.

343. VERONICA L.

670. (3485.) V. arvensis L. Corn Speedwell.
Cultivated grounds; frequent. April 13.

671. (3490.) V. peregrina L. Neckweed. Purslane Speedwell,
Waste and cultivated grounds; common. April 13.

672.* (3491.) V. serpyllifolia L. Thyme-leaved Speedwell.
Roadsides and fencerows; common. April 25.

344. LEPTANDRA Nutt.

673.* (3494.) L. virginica (L.) Nutt. Culver's root. Culver's Physic.
(*Veronica virginica* L.)
Borders of rich, moist woods and prairies; frequent. July 10.

345. WULFENIA Jacq.
(*Synthyris* Benth.)

674.* (3495.) W. houghtoniana (Benth.) Greene.
(*Synthyris houghtoniana* Benth.)
Dry, sandy hillsides; rare.
One-half mile southeast of Five-mile Pond.
Not reported south of Tippecanoe County.

346. AFZELIA J. G. Gmel.

(*Seymeria* Pursh.)

675. (3498.) A. MACROPHYLLA (Nutt.) Kuntze. Mullein Foxglove.
(*Seymeria macrophylla* Nutt.)
Banks of streams and open hillsides; scarce.
Beach's woods. Coal Creek. July 12.

347. DASYSTOMA Raf.

(*Gerardia* L. in part.)

676. (3499.) D. FLAVA (L.) Wood. Downy False Foxglove.
(*Gerardia flava* L.)
Dry, wooded hillsides; scarce.
Coal Creek. Hipple's Coal-mine woods.

677. (3503.) D. VIRGINICA (L.) Britton. Smooth False Foxglove.
(*Gerardia quercifolia* Pursh.)
Noted only in the thick woods southwest of the station at Heckland. September 10.

348. GERARDIA L.

678.* (3514.) G. TENUIFOLIA Vahl. Slender Gerardia.
Dry hillsides and sandy banks; frequent. September 5.

349. CASTILLEJA Mutis.

679.* (3519.) C. COCCINEA (L.) Spreng. Scarlet Painted Cup. Indian Pink.
Virgin prairie soil.
Noted only at Heckland, where it is common. April 28.

350. PEDICULARIS L.

680.* (3530.) P. CANADENSIS L. Common Lousewort. Wood Betony.
Dry, wooded hillsides or sandy woods; scarce.
Heckland. Coal Creek. April 25.

681.* 3535. (P.) LANCEOLATA Michx. Lousewort.
Ditches and low, waste places; scarce.
Van. Railway near Beach's. Heckland.

OROBANCHACEÆ Broom-rape Family.

351. THALESIA Raf.
(*Aphyllon* Mitch.)

682. (3557.) T. UNIFLORA (L.) Britton. One-flowered Cancer-root. (*Aphyllon uniflorum* Gray.)

Rare. Taken by U. O. Cox, May 8, 1890, in woods near Seventh Street bridge across Fall Creek.

352. OROBANCHE L.

683. (3558.) O. LUDOVICIANA Nutt. Broom-rape. (*Aphyllon ludovicianum* Gray.)

Banks of Wabash River, near brick yards above Terre Haute; frequent locally. Parasitie on the roots of the Great Horse-weed, *Ambrosia trifida* L. Discovered by Professor Evermann, October 2, 1889.

The first record for the State.

353. CONOPHOLIS Wallr.

684.* (3561) C. AMERICANA (L. f.) Wallr. Squaw-root. Cancer-root.

Open oak woods; scarce. May 12.

Southeast of Hunt's. Coal Creek. Cox's woods.

354. EPIPHEGUS Nutt.

685. (3562.) E. VIRGINIANA (L.) Bart. Beech-drops.

Dense beech woods; common. August 20.

BIGNONIACEÆ. Bignonia Family.

355. TECOMA Juss.

686. (3564.) T. RADICANS (L.) DC. Trumpet-creeper. Trumpet-flower.

Moist, rich or sandy soil, along fence-rows and banks; common. June 10.

Queen of all our creeping or trailing shrubs is the trumpet-creeper with its large pinnate leaves and giant, trumpet-like flowers, the latter so attractive to humming-bird and bumble-bee. Midsummer is the time, and the banks of the old canal the place, to see this creeper in all its primitive beauty. There the soil is congenial, and bush and shrub furnish a ready support to which its aerial rootlets freely cling; thus forming many a snug retreat in which the nest of woodland songster is securely hidden.

356. CATALPA Scop.

687. (3566.) C. **SPECIOSA** Warder.
Loose, rich, sandy soil along fence-rows; frequent.
This species grows indigenously in the southern half of the county, and in the Wabash valley as far north as Atherton. May 22.

PEDALIACEÆ. Pedalia Family.

357. MARTYNIA L.

688. (3567.) M. **LOUISIANA** Mill. Unicorn Plant.
(*M. proboscidea* Glox.)
Rich, loose, sandy soil; rare.
Roadsides northwest of Prairieton. (*Scovell.*)

ACANTHACEÆ. Acanthus Family.

358. RUELLIA L.

689.* (3569.) R. **CILIOSA** Pursh. Ruellia.
Dry, sandy soil along banks and fence-rows; frequent. June 1.

690. (3572.) R. **STREPENS** L.
Shady places in moist, rich soil; frequent. May 25.

359. DIANTHERA L.

691. (3574.) D. **AMERICANA** L. Water Willow.
In shallow water near ripples and edges of pools; common. June 20.

PLANTAGINACEÆ. Plantain Family.

360. PLANTAGO L.

692. (3577.) P. **ARISTATA** Michx.
P. patagonica aristata Gray.
E. & T. H. Railway and canal banks south of Terre Haute; scarce. June 24, 1888.
The first record for the State.

693. (3582.) P. **LANCEOLATA** L. Rib-grass. Ripple-grass. English Plantain.
Borders of old fields and waste, gravelly places; frequent, especially along the railways. May 25.

694. (3583.) P. **MAJOR** L. Common Plantain. Ribwort.
Door yards and roadsides; common. May 20.

695.* (3587.) P. RUGELII Dec.
Gravelly banks and roadsides; common. July 1.
Leaves larger and more shining than in *P. major*, and with the petioles often purple-tinged. The spikes longer, but less densely flowered.

696. (3589.) P. VIRGINICA L. Virginia Plantain. Ribgrass.
Roadsides and canal banks; common. May 8.

RUBIACEÆ. Madder Family.

361. HOUSTONIA L.

697. (3593.) H. CILIOLATA Torr.
(*H. purpurea ciliolata* Gray.)
Dry sandy hillsides; scarce.
Spring Hill; woods north of station. June 2.

698.* (3594.) H. CŒRULEA L. Bluets. Innocence.
Borders of moist prairies; noted only at Heckland, where it is abundant. May 7.

362. CEPHALANTHUS L.

699. (3601.) C. OCCIDENTALIS L. Button Bush. Elbow Brush.
Borders of ponds and marshes; common. July 3.

363. MITCHELLA L.

700. (3602.) M. REPENS L. Partridge Berry.
High wooded hills, trailing over the ground mosses; frequent.
Grant. Coal Creek. May 7.

364. GALIUM L.

701. (3606.) G. APARINE L. Cleavers. Goose Grass.
Sides of ravines and damp woods; common. April 28.

702. (3610.) G. CIRCÆZANS Michx. Wild Liquorice.
Rich open woods; common. May 2.

The old stems in late summer sometimes produce opposite, thickly-leaved branches from the axils of the whorls of the earlier, more remote leaves.

703.* (3612.) G. CONCINNUM T. and G.
Dry open woods and thickets; frequent. June 4.

704. (3623.) G. TINCTORIUM L.
(*G. trifidum tinctorium* Gray.)
Shaded fence-rows and dense woods; common. May 22.

705. (3625.) G. TRIFIDUM L. Small Bedstraw.
Thickets and damp, dense woods; common. May 12.

706.* (3626.) G. TRIFLORUM Michx. Sweet-scented Bedstraw.
Fence-rows and borders of open woods; common. May 12.

CAPRIFOLIACEÆ Honeysuckle Family.

365. SAMBUCUS L.

707. (3630.) S. CANADENSIS L. Common Elder.
Fence-rows and borders of cultivated fields; common. May 28.

366. VIBURNUM L.

708. (3634.) V. ACERIFOLIUM L. Dockmackie. Maple-leaved Viburnum.
High, wooded hills in dry soil; scarce.
Coal Creek. Grant. May 12.

709. (3637.) V. DENTATUM L. Arrow-wood.
Damp, dense woods and marshy thickets; scarce.
Heckland. S. W. ¼ of S. E. ¼ Sec. 6, Pierson Township. June 19.

710. (3639.) V. LENTAGO L. Sweet Viburnum. Sheep-berry.
Open woods, borders of streams, etc.; scarce.
Borders of marsh east of Beach's woods. Banks of Little Honey Creek in N. E. ¼ Sec. 36, Honey Creek Township. May 25.

711. (3640.) V. MOLLE Michx. Smooth-leaved Viburnum.
Fence-rows and margins of dry, upland prairies; scarce.
Roadside south of Youngstown in S. E. ¼ Sec. 35, Honey Creek Township. Found only in fruit, October 17, 1896.
The leaves, larger, more rounded, thicker and more soft downy, than those of *V. dentatum* L. Recorded before in Indiana only from Jefferson County.

712. (3645.) V. PRUNIFOLIUM L. Black Haw.
Fence-rows along dry upland fields; wooded slopes; scarce.
Ferrell's. Woods near Spring Hill. May 27.

367. TRIOSTEUM L.

713. (3648.) T. ANGUSTIFOLIUM L. Narrow-leaved Horse Gentian.
Moist woods and thickets; scarce.
Heckland. June 5.

714*. (3649.) T. PERFOLIATUM L. Feverwort. Horse Gentian.
Clearings and rich open woods; infrequent.
Heckland. Coal Creek. April 27.

368. SYMPHORICARPOS Juss.

715. (3654.) S. SYMPHORICARPOS (L.) MacM. Indian Currant. Coral Berry.

(*S. vulgaris* Michx.)

Gravelly or dry banks; scarce.

Sides of Van. Railway, one mile west of Glen. I. & St. L. railway near crossing of St Mary's road. June 30.

VALERIANACEÆ. Valerian Family.

369. VALERIANA L.

716. (3670.) V. PAUCIFLORA Michx. Valerian.

Ravines and rich wooded slopes in damp soil; scarce.

Grant. Honey Creek. Woods near Broadhurst's mine. May 10.

DIPSACEÆ. Teasel Family.

370. DIPSACUS L.

717. (3681.) D. SYLVESTRIS Huds. Wild Teasel.

Roadside in dry upland soil; scarce.

Grant. Roadside north of Cloverland, in Nevins Township. July 2.

CUCURBITACEÆ. Gourd Family.

371. MICRAMPELIS Raf.
(*Echinocystis* T. & G.)

718. (3686.) M. LOBATA (Michx.) Greene. Wild Cucumber. Wild Balsam Apple.

(*Echinocystis lobata* T. & G.)

Rich, moist soil along streams and river bottom ponds; common. July 14.

372. SICYOS L.

719. (3688.) S. ANGULATUS L. One-seeded Star Cucumber.

Borders of marshes and low places in the river bottoms; frequent. June 30.

CAMPANULACEÆ. Campanula Family.

373. CAMPANULA L.

720. (3689.) C. AMERICANA L. Tall Bellflower.

Moist, rich soil and shaded banks; common. June 5.

Varies much in height and the branching of the stem.

374. LEGOUZIA Durand.

(*Specularia* Heist.)

721. (3700.) L. **PERFOLIATA** (L.) Britton. Venus' Looking-glass
(*Specularia perfoliata* A. DC.)
Dry, barren or sandy soil; frequent. May 21.

375. LOBELIA L.

722. (3703.). L. **CARDINALIS** L. Cardinal Flower.
Low, damp soil; frequent. July 20.

723. (3706.) L. **INFLATA** L. Indian Tobacco.
Dry, open woods; common. July 12–November 4.

724. (3707) L. **LEPTOSTACHYS** A. DC.
Dry, sandy soil; scarce. July 1.
Along Van. Railway near Fair Ground.

725. (3715.) L. **SYPHILITICA** L. Great Blue Lobelia.
Low grounds; common. August 1.

Between this plant and the cardinal flower, members of the same genus, what a contrast in the color of the blossoms; those of the one bluer than the vault of heaven above, of the other redder than blood of the deepest dye, yet both too often unnoticed and unknown by the owner of the soil in which they grow.

COMPOSITÆ. Compositæ Family.

Especial attention was given to the collecting of the members of this, the highest family of flowering plants, and as a result 128 species and three varieties were found growing without cultivation in the parts of the county visited. This is, as far as known, the largest number of plants of this order found in any county in the State; the lists which have been prepared from the various counties having recorded the number of Compositæ as follows:

County.	Author.	Species.	Varieties.
Jefferson	Coulter	94	....
Delaware, Randolph, Jay and Wayne	Phinney	100	2
Franklin	Meyncke.	85	....
Fayette	Hesslar	71	....
Monroe	Blatchley	86	....
Steuben	Bradner	89	2
Noble	Van Gorder	79	2
The State	Barnes and Coulter	180	....

The Compositæ of Vigo County comprise more than one-seventh of the flowering plants so far found within its bounds. Among the forms collected no less than 51 are weeds,* while eight of them are included in the list of the "Twenty Worst Weeds," which, in the writer's opinion, grow in western Indiana.*

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*See definition of "weed" in Introduction to this paper, p 586.

Except from an æsthetic point of view, not one of the Compositæ noted below is of the least benefit to the inhabitants of the county, although a dose of dandelion tonic or boneset tea may occasionally be given by some grandmother or quack doctor for a fancied ailment. But the lover of nature, whose eye is ever on the search for the pleasing and the beautiful, blesses their existence; for the hues of the asters, goldenrods and sunflowers absent, our autumn scenery would lose much of the charm due to its variety of color.

Realizing the truth of the saying of a prominent American botanist: "That as for the *Asters* and *Solidagoes*, the older the botanist, the less high and mighty does he become concerning them," the specimens of those two genera were sent to Dr. J. M. Coulter for verification, and to him are due my especial thanks for the service thus rendered.

376. VERNONIA Schreb.

726. (3721.) V. FASCICULATA Michx. Iron-weed.

Open woods and pastures, especially in upland soil; very common. August 8.

Specimens with the flowers white are occasionally found.

In the great contest for supremacy, forever going on among all plants as well as among all animals, the rag-weed, fox tail, white top, etc., go down before the creeping, smothering power of the Kentucky blue grass; but this rough, ungainly weed ne'er gives up the struggle, and in many places grows as rankly in the farmer's best lowland pastures as does its cousin, the greater rag-weed or horse-weed, along the margins of his cultivated bottom fields. It is seemingly becoming more abundant each year, and at present is undoubtedly the worst weed with which the stock farmers of Indiana have to contend.

It has been said that all things in nature have their use—that nothing exists but for a purpose. It is the work of science to discover and make known the use of nature's objects; and day by day her secrets are gradually being exposed, thereby advancing man in civilization, by enabling him to better control the ravages of those existing forms which are injurious to his interests. If, however, the iron-weed has a use, other than that shown in the beauty of its flowers, no one has yet discovered it. But there is time; for of the thousands of plant forms which exist we know the use of only a few, as corn and hemp, ginseng and blood root. Let us hope that some valuable medicinal or other property will soon be discovered in the iron-weed and a reason for its existence thereby pointed out to the doubting humanity of the present.

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*See Introduction to this paper, p. 587.

Meanwhile the naturalist will go on admiring the beauty of its bloom, for however coarse and repulsive the stem and leaves may appear, yet each head, with its 25 or 30 dainty florets so prettily grouped within their protective cups, reveals a striking beauty to the true lover of nature; and when in the glamour of an August morn he stands upon a hillside and views acre upon acre of the broad, purple cymes waving in the valley beneath, all memories of the plant as a pernicious weed are blotted from his mind by the attractiveness of the scene before him.

727. (3725.) V. NOVEBORACENSIS (L.) Willd. Ironweed.
Prairies and woodlands of river terrace; common, but less so than the preceding.
Heckland. McKeen's woods, etc. August 21.

377. ELEPHANTOPUS L.

728.* (3728.) E. CAROLINIANUS Willd. Elephant's Foot.
Open, usually low woods in sandy soil; scarce.
McKeen's woods south of Fair Ground. Woods south of Vandalia Railway, opposite Beach's. September 10.

The smaller specimens from the last named locality came near to *E. tomentosus* L., the leaves being crowded at the base, the only truly stem-leaf being a small one subtending the lowermost peduncle.

378. EUPATORIUM L.

729. (3732.) E. AGERATOIDES L. f. White Snake-root.
Open woods, roadsides, etc.; common. July 21.

730.* (3738.) E. CŒLESTINUM L. Mist-flower.
Rich, damp soil; scarce.
Bottom lands northwest of Conover's Pond. Coal Creek bottoms. September 8.

731. (3744.) E. PERFOLIATUM L. Thoroughwort. Boneset.
Low, damp places; common. July 17.

732. (3747.) E. PURPUREUM L. Joe Pye Weed. Trumpet Weed. Purple Boneset. Queen of the Meadow.
Low, damp, open woods and borders of marshes; common. July 20.

733.* (3752.) E. SEROTINUM Michx.
Gravelly banks and borders of prairies; frequent.
Heckland. Vandalia Railway. September 5.

379. KUHNIA L.

734. (3758.) K. EUPATORIOIDES L.
Sandy banks and prairies; frequent. August 11.

380. LACINARIA Hill.

(*Liatris* Schreb.)

735.* (3765.) L. PYCNOSTACHYA (Michx.) Kuntze.
(*Liatris pycnostachya* Michx.)
Rare. Several specimens were taken at Heckland, September 5, 1889.

736.* (3766) L. SCARIOSA (L.) Hill. Gay Feather. Button Snakeroot.
(*Liatris scariosa* Willd.)
Borders of prairies; scarce.
Heckland. T. H. & L. R. R. above Otter Creek Junction. August 17.
The heads often one and one-half inches in diameter.

737. (3769.) L. SPICATA (L.) Kuntze.
(*Liatris spicata* Willd.)
Borders of damp prairies; scarce.
Heckland. August 17.

381. CHRYSOPSIS Nutt.

738.* (3788.) C. VILLOSA (Pursh) Nutt. Golden Aster.
Sandy banks and borders of prairies; scarce.
Along the canal, between Ft. Harrison and Five-Mile Pond. June 24.
The first record for the State; its range being given as "Wisconsin to Kentucky and westward."

382. SOLIDAGO L. The Golden-rods.

739.* (3808.) S. CÆSIA L.
Borders of damp woods and sides of ravines; common. September 5.

740.* (3810.) S. CANADENSIS L.
Fence-rows, roadsides, etc. ; common. August 5 to November 15.

740a. (3813.) S. CANADENSIS SCABRIUSCULA Porter.
(*S. canadensis scabra* T. and G.)
With the preceding; scarce.
Heckland; Van. Railway.

741.* (3819.) S. FLEXICAULIS L.
(*S. latifolia* L.)
Damp, wooded slopes and ravines; frequent. September 1.

742. (3833.) S. NEMORALIS Ait.
Dry prairies; frequent. August 18.

743. (3834.) S. ODORA Ait. Sweet Golden-rod.
Borders of prairies; rare.
Heckland. September 15.

Recorded before in Indiana only from Gibson County.

744.* (3843.) S. RIGIDA L.
Margins of prairies; scarce.
Heckland. T. H. & L. R. R. August 20.

A most handsome species; very variable in height and size of corymb of flowers.

745.* (3844.) S. RIGIDIUSCULA (T. & G) Porter.
(*S. speciosa angustata* T. & G.)
Clearings and borders of prairie at Heckland: not noted elsewhere. September 5.

The first record for the State.

746. (3845.) S. RUGOSA Mill.
Borders of open fields and thickets; common. August 8.

Very variable; the leaves of shaded swamp forms being thin and much less rugose than those in open dry places. Well developed specimens of the latter are very handsome, having the flowering branches several and very long recurved spreading.

747.* (3848.) S. SEROTINA Ait.
Rich bottom woods; scarce.
Woods on bank of Wabash River below Ft. Harrison. September 8.

748*. (3851.) S. SPECIOSA Nutt.
Borders of prairies; frequent at Heckland. August 25, 1889.

The first record for the State.

749. (3857.) S. ULMIFOLIA Muhl.
Damp wooded hillsides; frequent.
Coal Creek. Grant. September 5.

383. EUTHAMIA Nutt.
(*Solidago* L. in part.)

750. (3864.) E. CAROLINIANA (L.) Greene.
(*S. tenuifolia* Pursh.)
Shaded banks, usually in sandy soil; frequent. August 21.

751.* (3865.) E. GRAMINIFOLIA (L.) Nutt.
(*S. lanceolata* L.)
Damp, low soil; common. August 10.

384. BOLTONIA L'Her.

752. (3874.) B. ASTEROIDES (L.) L'Her.
Low, open pastures and prairies; scarce.
McKeen's Woods. Heckland. September 14.

385. SERICOCARPUS Nees.

753. (3880.) S. LINIFOLIUS (L.) B. S. P.
(*S solidagineus* Nees.)
Borders of prairies; scarce.
Heckland. August 18.
Before recorded in Indiana only from Floyd County.

386. ASTER L.

754. (3886.) A. AZUREUS Lindl. Azure Aster.
Borders of prairies; rare.
Heckland. August 25.

755. (3889.) A. CORDIFOLIUS L. Heart-leaved Aster.
Dry, wooded hillsides; common. September 11.
In flower later than most others of the genus.

756.* (3892.) A. DRUMMONDII Lindl. Drummond's Aster.
Low, open pastures and prairies; frequent.
Heckland. Sides of Van. Railway, etc.
The first record for the State, its range being given by Gray as "Illinois to Minnesota and Kansas."

757. (3893.) A. DUMOSUS L.
Dry open woods and fence-rows; frequent. September 8.

758.* (3897.) A. ERICOIDES L. Heath-like Aster.
Fence-rows in open, dry soil; scarce.
Roadside near Spring Hill. Coal Creek.

758a.* (3898.) A. ERICOIDES PILOSUS (Willd.) Porter.
(*A. ericoides villosus* T. and G)
In similar localities, but more frequent.

759.* (3911.) A. LÆVIS L. Smooth Aster.
Dry prairie soil; scarce.
Heckland. Hillside at Five-Mile Pond. September 5.
A handsome but variable species.

760. (3913.) A. LATERIFLORUS (L.) Britton. Diffuse Aster.
(*A. diffusus* Ait.)
Open waste places; common, especially in upland soil.
A much branched, small-flowered and variable species.

761. (3917.) A. LINARIIFOLIUS L. Double Bristled Aster.
Dry sandy hillsides; scarce.
Hillside at Five-Mile Pond. September 10.

Readily known by the shortness of the stems, which grow in clumps, and by the rigid, linear leaves. Heads large and showy.

762. (3926.) A. MULTIFLORUS Ait. Many-flowered Aster.
Sandy or barren soil; frequent.
Banks and bed of the old canal. September 15.

763.* (3929.) A. NOVÆ-ANGLIÆ L. New England Aster.
Moist open ground; common. September 10.

One of our most striking species; its large violet-purple heads rendering it easily recognized after a first acquaintance.

764.* (3937.) A. PANICULATUS Lam.
Open, damp places; common. September 10.

765.* (3938.) A. PATENS Ait.
Dry prairies and sandy hillsides; frequent locally.
Hillside at Five-Mile Pond. Heckland. August 20.

766.* (3945.) A. PUNICEUS L.
Moist, open woods and borders of marshes; common.
Our tallest and roughest-stemmed species. September 15.

767. (3951.) A. SAGITTÆFOLIUS Wedem. Arrow leaved Aster.
Borders of fields and open woods; common.

768.* (3952.) A. SALICIFOLIUS Lam. Willow-like Aster.
Low, moist soil; common.

This and *A. paniculatus* Lam. cover large areas in the annually overflowed bottoms along the Wabash River.

769.* (3955.) A. SHORTII Lindl.
Moist, shaded banks; scarce.
Ravines east of Highland Lawn Cemetery. September 25.

770. (3962.) A. TRADESCANTI L.
Low, open grounds; frequent. September 5.

771. (3967.) A. UNDULATUS L. Wavy Aster.
Dry, open woods and thickets; frequent.
Coal Creek. Hipple's Woods, etc. September 8.

387. ERIGERON L.

772.* (3973) E. ANNUUS (L.) Pers. Daisy Fleabane. White-top.
Waste grounds and clover and timothy meadows; abundant. May 25.

773. (3977.) E. CANADENSIS L. Horse-weed. Butter-weed.
Cultivated fields and open, waste places; abundant. July 3.

774. (3983.) E. PHILADELPHICUS L. Common Fleabane.
Low, grassy places, banks, etc.; frequent. April 12, 1888. April 20, 1889.

775.* (3984) E. PULCHELLUS Michx. Robin's Plantain.
(*E. bellidifolius* Muhl.)
Damp woodlands and borders of prairies; scarce.
Heckland. Beach's woods. May 13.

776. (3986.) E. RAMOSUS (Walt.) B. S. P. Daisy Fleabane.
(*E. strigosus* Muhl.)
Meadows and waste open grounds; common. May 25.

This species and *E. annuus* Pers. are the most pernicious weeds with which the growers of timothy or clover have to contend. Both are commonly known as "white-top," and are not separated by the average farmer. *Ramosus* may be readily distinguished, however, by its smaller size, its narrower, nearly entire leaves, and smaller, longer rayed flowers.

388. ANTENNARIA Gaertn.

777. (4004.) A. PLANTAGINIFOLIA (L.) Richards. Plantain-leaved Everlasting. Cat's-paw. Mouse-ear.
Dry, open woods and banks; common. April 4.

The earliest flowering of the Compositæ; quickly followed, however, by *Erigeron philadelphicus* L. and *Senecio aureus* L.

389. GNAPHALIUM L.

778. (4008.) G. OBTUSIFOLIUM L. Common Everlasting.
(*G. polycephalum* Michx.)
Old fields and open woods; common. August 20.

779.* (4010.) G. PURPUREUM L. Purplish Cudweed.
Dry, open woods; frequent.
Heckland. Coal Creek. June 1.

In Gray's Synoptical Flora the range of this species is given as: "Chiefly of sea coast or near it; coast of Massachusetts to Texas and interior of Arkansas." In the Catalogue of Indiana Plants it is mentioned without comment, which signifies that it is found throughout the State.

390. INULA L.

780. (4014.) I. HELENIUM L. Elecampane.
Old fields and banks of roadsides in dry upland soil; scarce.
North of I. & St. L. bridge across St. Mary's road. Grant.

391. POLYMNIA L.

781. (4016.) P. CANADENSIS L. Leaf cup.
Shaded ravines; frequent.
Coal Creek. Grant. June 16.

The rays are usually three-lobed, and whitish, and the plant very strongly and disagreeably scented.

392. SILPHIUM L.

782. (4023.) S. PERFOLIATUM L. Cup-plant.
Borders of streams and ditches; scarce.
Side of railway near Spring Hill. Woods south of Vandalia Railway, opposite Beach's. July 27.

783. (4024.) S. TEREBINTHACEUM Jacq. Prairie Dock. Rosin Plant.
Prairies and roadsides; scarce.
Heckland. Roadsides below Youngstown. August 1.

393. PARTHENIUM L.

784. (4032.) P. INTEGRIFOLIUM L. Parthenium.
Dry prairie or sandy soil; scarce.
Heckland. T. H. & L. Railway above Otter Creek Junction. June 8.

Grows in dense tufts.

394. AMBROSIA L.

785. (4039.) A. ARTEMISIÆFOLIA L. Ragweed. Roman Wormwood. Hogweed. Bitterweed.
Waste places, cultivated grounds, etc.; abundant.

Probably the worst weed with which the farmers of Vigo County have to deal. Excessively abundant in 1896, due, doubtless, to the many rains of the season.

A smaller form, fifteen inches high, very viscid, with all the leaves cut-cleft or only once pinnatifid, grows on the hillside near Five-Mile Pond. It is in flower until October 15, and is distinguished at a glance from the ordinary form.

786. (4040.) A. BIDENTATA Michx. Two-toothed Ragweed.
Roadsides and borders of cultivated fields between Glen and Staunton, Clay County; common locally. First noted August 23, 1895.

The first record for the State.

787. (4042.) A. TRIFIDA L. Great Ragweed. Horseweed.
Alluvial soil along streams; abundant. August 5.

One of the tallest of our annual plants, often reaching thirteen, and occasionally fourteen, feet in height. Horses are very fond of it, and in August and September large quantities are gathered for their use by the poorer classes who can not afford to buy hay.

787 a. (4043.) A. TRIFIDA INTEGRIFOLIA (Muhl.) T. & G.
With the species, but scarce.

395. XANTHIUM L.

788. (4047.) X. CANADENSE Mill. Cockle-bur.
Alluvial or overflowed bottom lands; abundant. August 10.

The form known as var. *echinatum* Gray, with the prickles of the bur long, dense and very hispid, occurs sparingly along the canal and at Heckland.

789. (4049.) X. STRUMARIUM L. Cockle-bur. Clot-bur.
Roadsides, barnyards and upland cultivated grounds; frequent. August 10.

396. HELIOPSIS Pers.

790.* (4051.) H. HELIANTHOIDES (L.) B. S. P. Smooth Ox-eye. False Sunflower.
(*H. lævis* Pers)
Thickets and fence rows in dry soil; frequent. July 12.

791.* (4052.) H. SCABRA Dunal. Rough Ox-eye.
In similar localities with the preceding, but more common. July 15.

397. ECLIPTA L.

792. (4053.) E. ALBA (L.) Hassk.
Borders of ponds and low wet places; frequent. July 16.

The short peduncled form is, as yet, the only one found in the county.

398. RUDBECKIA L.

793. (4057.) R. HIRTA L. Yellow Daisy. Black-eyed Susan. Meadow Cone-flower.
Dry meadows; frequent. June 10 to November.

Appears to be both an annual and a biennial; in the former case lower and more simple stemmed and blooming in late autumn; as a biennial, stouter, more branched and blossoming early.

794. (4058.) R. LACINIATA L.
Damp woods and banks of railways; frequent. July 25.

795. (4063.) R. TRILOBA L. Small flowered Cone-flower. Darkey-head.
Banks and borders of ditches and damp meadows; common. July 25.
One of the most showy of our common Compositæ.

399. LEPACHYS Raf.

796.* (4065.) L. PINNATA (Vent.) T. & G.
Dry banks and prairies; scarce. June 29.

Leaves very rough on both sides.

400. BRAUNERIA Neck.
(*Echinacea* Moench.)

797. (4068.) B. PURPUREA (L.) Britton. Purple Coneflower.
(*Echinacea purpurea* Moench.)
Prairies and dry sandy hillsides; scarce.
Heckland. Hillside southeast from Five-Mile Pond. July 20.

401. HELIANTHUS L.

798. (4072.) H. ANNUUS L. Common Sunflower.
Low waste grounds, escaped from cultivation; scarce.
A number grow each year along the borders of the old canal.

799. (4074.) H. DECAPETALUS L.
Low thickets and banks of streams; common. August 10.

800. (4075.) H. DIVARICATUS L. Divaricate-leaved Sunflower.
Prairies and borders of sandy cultivated fields; frequent.
Heckland. Banks of canal, etc. July 20.

A characteristic and easily known species; the leaves rarely in whorls of three.

801 (4077.) H. GIGANTEUS L.
Borders of marshes and low wet places; frequent. August 20.

802. (4078.) H. GROSSE-SERRATUS Martens.
Dry prairies and fence-rows; frequent. August 25.

A specimen with leaves nearly entire, and measuring 12 feet 1 inch in height, was taken in the border of damp woods, in S. E. ¼, Sec. 6, Pierson Township.

803. (4079.) H. HIRSUTUS Raf.
Borders of upland woods; scarce.
Sand Hill. Ferrell's. July 25.

804. (4080.) H. LÆTIFLORUS Pers.
Prairies and fence-rows; frequent. August 15.

805.* (4083.) H. mollis Lam.
Dry, sandy or prairie soil; frequent.
Five-Mile Pond. Heckland. August 12.

Readily distinguished by the soft, whitish pubescence of the opposite, sessile, somewhat divaricate leaves.

806. (4085.) H. occidentalis Riddell.
Dry prairies; rare.
Heckland. August 4.

807. (4087.) H. microcephalus T. & G. Small-flowered Sunflower.
(*H. parviflorus* Bernh.)
Dry, upland woods; frequent.
Coal Creek. Hipple's Coal-mine woods, etc. August 20.

808. (4095.) H. trachelifolius Mill.
Fence-rows and along railways; frequent. July 25.

809. (4096.) H. tuberosus L. Jerusalem Artichoke.
Alluvial soil along streams; frequent. August 25.

A coarse, large-leaved species, blooming a week or two later than its its allies.

402. VERBESINA L.

(*Actinomeris* Nutt. in part.)

810. (4099.) V. alternifolia (L.) Britton.
(*Actinomeris squarrosa* Nutt.)
Bottoms of ravines and low, rich soil; frequent. August 18.

811. (4101.) V. helianthoides Michx. Crownbeard.
Borders of damp prairies; scarce.
Near Goose Pond. Heckland, one-half mile west of station. June 22.

Heads often several, on long peduncles from the axils of the leaves.

403. COREOPSIS L.

812.* (4109.) C. lanceolata L. Tickseed.
Dry, sandy knolls; scarce.
Hillside near Five-Mile Pond. Durkey's Ferry. May 25.

813. (4116.) C. tripteris L. Tall Coreopsis.
Borders of prairies and along railways in dry soil; scarce.
Heckland. T. H. & L. Railway above Otter Creek Junction.

A depauperate form less than three feet high occurs in the damp woods at Heckland.

404. BIDENS L.

814. (4124.) B. BIPINNATA L. Spanish Needles.
Thickets and waste places; frequent. July 25.

815. (4125.) B. CERNUA L. Smaller Bur-Marigold.
Ditches and mucky margins of ponds; common. August 1.

816.* (4126.) B. CONNATA Muhl. Swamp Beggar-ticks.
Border of swamps and marshes; common. July 25.

817. (4129.) B. FRONDOSA L. Common Beggar-ticks.
Low, waste places; abundant. July 5.

818.* (4130.) B. LÆVIS (L.) B. S. P. Larger Bur-Marigold.
(B. *chrysanthemoides* Michx.)
Low, wet or alluvial soil; frequent. August 10.

405. HYMENOPAPPUS L'Her.

819.* (4139.) H. CAROLINIENSIS (Lam.) Porter.
(*H scabiosæus* L'Her.)
Dry, sandy hillsides; rare.
Taken only on the hillside northeast of Seventh Street bridge across Lost Creek. May 31, 1890.

The first record for the State; its range being given in the Manual as "Illinois and southward."

406. DYSODIA Cav.

820. (4149.) D. PAPPOSA (Vent.) A. S. Hitchc. Fetid Marigold. False Dog-fennel.
(*D. chrysanthemoides* Lag.)
Roadsides and along railways; common. August 4.

A railroad migrant from the far West; seemingly displacing in many localities the common dog-fennel, *Anthemis cotula* L. The odor of the latter was bad enough, but that of the fetid marigold is infinitely more disgusting.

407. HELENIUM L.

821.* (4151.) H. AUTUMNALE L. Sneeze weed.
Low, moist places, especially along streams; common. July 27.

822. (4153.) H. NUDIFLORUM Nutt.
Low, damp soil; scarce.
McKeen's woods. Vandalia Railway, near Glen. June 20.

408. ACHILLEA L.

823. (4163.) A. MILLEFOLIUM L. Common Yarrow. Milfoil.
Old meadows and roadsides; frequent. May 27.

409. ANTHEMIS L.

824. (4166.) A. COTULA DC. May-weed. Dog-fennel.

Roadsides and waste upland grounds; common. June 20 to November.

410. CHRYSANTHEMUM L.

825. (4171.) C. LEUCANTHEMUM L. Ox-eye Daisy. White-weed. Marguerite.

Old meadows and closely cropped upland pastures; scarce.

Pasture by roadside one-half mile west of Ferrell's. Fields west of Macksville. June 13.

411. TANACETUM L.

826. (4178.) T. VULGARE L. Common Tansy.

Roadsides and along railways, escaped; scarce.

T. H. & E. Railway, one-half mile below blast furnace, north of St. Mary's.

412. ARTEMISIA L.

827.* (4182.) A. BIENNIS Willd. Biennial Wormwood.

Sandy banks and waste places; common. July 17.

A homely, coarse weed with a rank, disagreeable odor.

413. ERECHTHITES Raf.

828. (4209.) E. HIERACIFOLIA (L.) Raf. Fire-weed.

Borders of rich, open woods and clearings where the soil has recently been burned over; common. July 15.

414. SENECIO L.

829. (4210.) S. AUREUS L. Golden Ragwort. Squaw-weed.

Ditches and borders of swamps; scarce.

Southeast of Hunt's Rosary. Marsh near Beach's woods. Heckland. April 17.

830. (4219.) S. LOBATUS Pers. Butter-weed.

Margins of ponds; scarce.

Conover's Pond. Van. Railway, near Beach's woods. May 21.

The first record for the State. Note range as given in Manual.

831. (4220.) S. OBOVATUS Muhl.

(*S. aureus obovatus* T. & G.)

Dry hillsides and railway banks; frequent. April 17.

415. CACALIA L.

832. (4231.) C. ATRIPLICIFOLIUS L. Pale Indian Plantain.

Dry banks and wooded hillsides; frequent.

Heckland. T. H. & L. Railway. Coal Creek.

833. (4232.) C. **reniformis** Muhl. Great Indian Plantain.
Rich, damp soil; rare.
Along a small stream one-fourth of a mile south of the top of Coal Creek Hill. June 25.

416. ARCTIUM L.

834. (4235.) A. **lappa** L. Common Burdock.
Dooryards of deserted dwellings and waste places; common. July 10.

417. CARDUUS L.

(*Cnicus* Tourn.)

835.* (4238.) C. **altissimus** L. Tall Thistle.
(*Cnicus altissimus* Willd.)
Fence-rows and borders of woods; frequent. June 20.

836.* (4241.) C. **discolor** (Muhl.) Nutt.
(*Cnicus altissimus discolor* Gray.)
With the preceding and more frequent; June 2.

The wool on under side of the pinnatifid leaves is much thicker and the scales of involucre more glandular than in *C. altissimus*. Insects are frequently entrapped by the exudation of the glands. (*Vide* Canadian Entomologist, XXIV, 1892, 310.)

837. (4243.) C. **lanceolatus** L. Common Thistle.
(*Cnicus lanceolatus* Willd.)
Pastures and roadsides; abundant. July 5.

838. (4244.) C. **muticus** (Michx.) Pers. Swamp Thistle.
(*Cnicus muticus* Pursh.)
Borders of prairie marshes and ditches; scarce.
Heckland.

418. ADOPOGON Neck.

(*Krigia* Schreb.)

839. (4268.) A. **virginicum** (L.) Kuntze. Cynthia.
(*Krigia amplexicaulus* Nutt.)
Borders of woodlands in rich, rather dry soil; frequent. May 28.

419. HIERACIUM L.

840. (4285.) H. **gronovii** L. Hairy Hawkweed.
Sandy hillsides and open woods; scarce.
Beach's. Five-Mile Pond. August 20.

841. (4286.) H. LONGIPILUM Torr. Long-bearded Hawkweed.
Open sandy woods and dry hills; scarce.
Coal Creek. Beach's. August 20.

842.* (4293.) H. SCABRUM Michx. Rough Hawkweed.
Dry wooded hillsides; frequent. August 10.

420. TARAXACUM Hall.

843. (4303.) T. TARAXACUM (L.) Karst. Common Dandelion. Priest's Crown.
(*T. officinale* Weber.)
Pastures, yards and roadsides; abundant. March 28 to November.

421. LACTUCA L.

844. (4308.) L. CANADENSIS L. Wild Lettuce. Trumpet Milk-weed.
Borders of thickets and roadsides; frequent. July 18.

845. (4310.) L. HIRSUTA Muhl. Hairy Wild Lettuce.
Borders of prairies and dry, sandy places; scarce.
Heckland. Banks of canal, etc. September 5.

846. (4313.) L. SAGITTÆFOLIA Ell. Entire-leaved Wild Lettuce.
(*L. integrifolia* Bigel.)
Fence-rows of cultivated fields and roadsides; common. August 4.

847.* (4314.) L. SCARIOLA L. Prickly Lettuce.
Waste places along railways, roadsides and streets; common. June 20.

For general accounts of the plant, notes of its first appearance in Indiana, etc., *Vide* "Purdue Agr. Exp. Stat. Bull.," No. 52, 1894, and 'Indiana Farmer," July 27, 1895.

848. (4315.) L. SPICATA (Lam.) A. S. Hitchc. Tall False Lettuce.
(*L. leucophæa* Gray.)
Borders of upland thickets in moist, rich soil; frequent.

One specimen measuring 14 feet 4 inches in height was the tallest, upright, herbaceous plant recorded from the county.

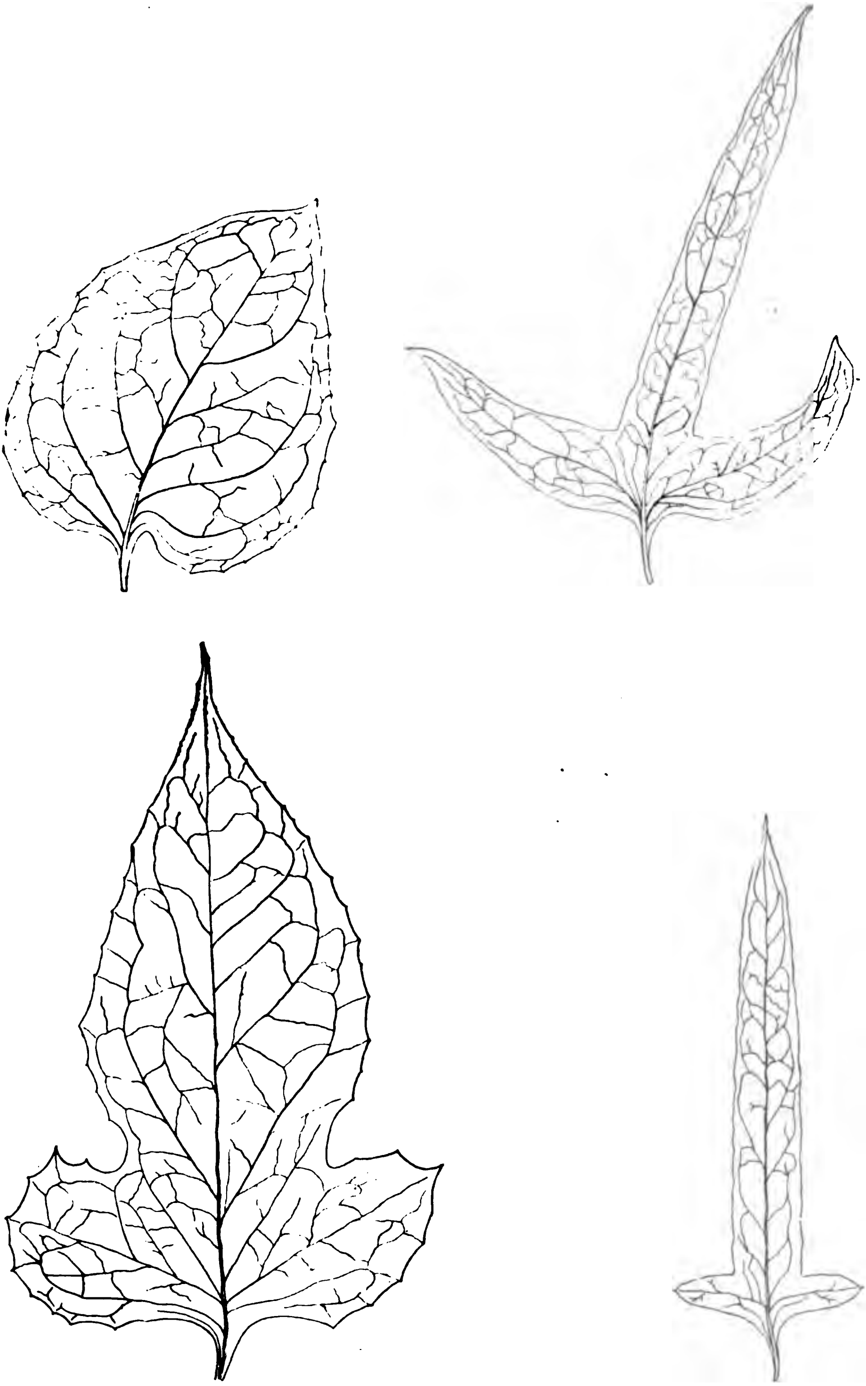
849. (4317.) L. VILLOSA Jacq. False Wild Lettuce.
(*L. acuminata* Gray.)
Fence rows and borders of thickets; frequent. September 5.

422. PRENANTHES L.

850. (4318.) P. ALBA L. White Lettuce. Rattlesnake Root.
Open woods and waste, sandy soil; frequent. August 5.

851. (4319.) P. ALTISSIMA L. Tall White Lettuce.
Borders of woods in rich moist soil; common. August 20.

The leaves more variable than those of any other flowering plant.



EXAMPLES OF VARIATION IN THE FORM OF THE LEAVES OF WHITE LETTUCE,
***Prenanthes altissima* L.**

423. SONCHUS L.

852. (4329.) S. ASPER (L.) All. Spiny-leaved Sow Thistle.
Low waste grounds in the city and along railways; frequent. June 25.

853. (4330.) S. OLERACEUS L. Common Sow Thistle.
Roadsides and waste places in the city; scarce. May 10.

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ERRATA.

PAGE.	
151.	Fourteenth line from top, *augur* should be auger. The same mistake occurs a number of times thereafter.
296.	Fourth line from top, Chester *and* should be Chester or.
302.	Eighteenth line from bottom, *salt* should be silt.
303.	First line, *draining* should be damming.
312.	First line, *this* should be thus.
338.	After Fig. 11 the word *small* should be omitted.
340.	Nineteenth line from top, *comforable* should be comfortable.
377.	Top of page, *Bedeord* should be Bedford.
409.	Tenth line from top, *Oloitic* should be Oölitic.
411.	Tenth line from bottom, *1678* should be 1878.
508.	Eighth line from bottom, *birch* should be beech.
512.	Fifteenth line from bottom, *corbonate* should be carbonate. *Same* in the next line should be some.
546.	First line, *inclinse* should be incline.
576.	Third line from bottom, *Deill* should be Diall.
594.	Number 33, omit the period after *fruiting*.
607.	Second line from top, for *Fal* read False.

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